

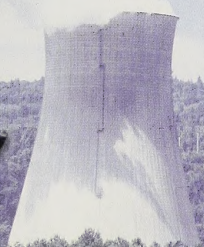


SCIENCE 9

Module


3

Environmental Chemistry



Learning
Technologies
Branch

Alberta
LEARNING



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SCIENCE 9

Module

3

Environmental Chemistry



Science 9
Module 3: Environmental Chemistry
Student Module Booklet
Learning Technologies Branch
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The Learning Technologies Branch acknowledges with appreciation the Alberta Distance Learning Centre and Pembina Hills Regional Division No. 7 for their review of this Student Module Booklet.

This document is intended for	
Students	✓
Teachers	✓
Administrators	
Home Instructors	
General Public	
Other	



You may find the following Internet sites useful:

- Alberta Learning, <http://www.learning.gov.ab.ca>
- Learning Technologies Branch, <http://www.learning.gov.ab.ca/lrb>
- Learning Resources Centre, <http://www.lrc.learning.gov.ab.ca>

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WELCOME

to Science 9!

It is recommended that you work through the modules in order because the concepts and skills introduced in one module will be reinforced, extended, and applied in later modules.

Module 1 Biological Diversity

Module 2 Matter and Chemical Change

Module 3 Environmental Chemistry

Module 4 Electrical Principles and Technologies

Module 5 Space Exploration

Module 1 contains general information about the course components, additional resources, icons, assessment, and strategies for completing your work. If you do not have access to Module 1, contact your teacher to obtain this important information.

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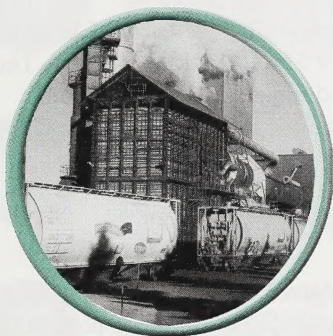
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Resources

Textbook

To complete the course, you need the textbook *ScienceFocus 9*.

Multimedia

Attached to Student Module Booklets in this course are CDs titled *Science 9 Multimedia* and *Science 9 Multimedia: Astronomy*. These CDs contain multimedia segments designed to help you better understand particular concepts presented in this course. Ask your teacher or home instructor if you need help using these CDs.

Materials and Apparatus

A list of materials and apparatus is given on the Planning Ahead page of each Student Module Booklet. These items are needed to complete the module. Some of the materials and apparatus may be provided at your local school lab. If you don't have access to a school lab, you will need to get the loan kit. Talk to your teacher for more information.

Before You Begin

Organize your materials and work area before you begin: Student Module Booklet, textbook, notebook, pens, pencils, and so on. Make sure you have a quiet area in which to work, away from distractions.

Because response lines are not provided in the Student Module Booklet, you'll need a looseleaf binder or notebook to respond to questions and complete charts. It's important to keep your lined paper handy as you work through the material and to keep your responses together in a notebook or binder for review purposes later.

Refer to the Planning Ahead page for directions on what you need to do before you start this module.

Good luck!

Icons

This is one of five Student Module Booklets for Science 9. As you progress through this module, you will meet several icons.



Do Ahead

Some preparation must be started well ahead of the activity or investigation. E.g., start the seedlings for the investigation in Lesson 3.



Teacher or Home Instructor

The teacher or home instructor should be contacted for help, approval of some procedure, or checking answers.



Assignment Booklet

Work needs to be done in an Assignment Booklet.



Safety

You must be very careful when you see this symbol.



Textbook

A reference is made to *ScienceFocus 9*, the student textbook for this distance learning course.



Internet

This is a reference to the Internet. **Note:** Any Internet website given is subject to change.



Multimedia

This is a reference to the *Science 9 Multimedia* CDs.



Computer

You will need to work with a computer when you see this symbol.

Module Overview

Waste is a normal product of your daily life and lifestyle. That chocolate bar wrapper, potato chip bag, and soft drink bottle have to go somewhere. But where? And what about the wastes created during the production of clothing and electronic equipment? Answers to such questions can be looked at from the perspective of matter and chemical change.

Section 1 Environmental Quality

Section 2 The Problem of Pollution

Environmental chemistry is a branch of science that studies the environment and environmental issues from a chemistry viewpoint—a viewpoint you used in Module 2: Matter and Chemical Change. Your health, the health of your local and global environment, and waste treatment are in the spotlight in Module 3. This module builds on many concepts you have already studied in junior high science.

In this module you will investigate the role of chemical substances in supporting or harming humans and other living things in the environment. You will find out how to measure chemical substances in the environment and how to monitor air and water quality. You will also look at ways in which harmful substances can spread and affect an environment. Both you and society have a responsibility to protect the environment.

Check out pages 174 to 177 of the textbook to help you see what's ahead in this module.

Assessment

The booklet you are presently reading is the Student Module Booklet. It will show you, step by step, how to advance through Module 3: Environmental Chemistry.

This module, Environmental Chemistry, has two sections. Within each section your work is grouped into lessons. Within the lessons there are readings, investigations, activities, and questions for you to do. By completing these lessons you will discover scientific concepts and skills, develop a positive attitude toward science, and practise or apply what you have learned.

Suggested answers in the Appendix of this Student Module Booklet will provide you with immediate feedback on the answers to questions in the lesson. Your teacher or home instructor will also provide you with feedback on your progress through the module.

At several points in this module you will be directed to an accompanying Assignment Booklet. Your grading in this module is based on the assignments you submit for assessment. In this module you are expected to complete two section assignments and a Final Module Assignment.

The mark distribution is as follows:

Assignment Booklet 3A	
Section 1 Assignment	66 marks
Assignment Booklet 3B	
Section 2 Assignment	37 marks
Final Module Assignment	<u>70 marks</u>
TOTAL	173 marks

Planning Ahead

Here is a list of materials and apparatus you will need to complete this module.

Section 1

- ☐ safety goggles
- ☐ an apron
- ☐ latex gloves
- ☐ a head of red cabbage
- ☐ 25 mung bean seeds or garden pea seeds
- ☐ four 50-mL beakers or four glasses
- ☐ five small, self-sealing plastic bags
- ☐ a variety of foods and household chemicals for testing
- ☐ baking soda
- ☐ a clean plastic straw
- ☐ coffee
- ☐ commercial fertilizer
- ☐ an eye dropper
- ☐ graph paper
- ☐ household ammonia
- ☐ a large pot (not aluminum)
- ☐ marking pens
- ☐ a measuring cup or a 100-mL graduated cylinder
- ☐ a metric ruler
- ☐ one or more clear, colourless containers or white soup or dessert bowls
- ☐ a pair of scissors
- ☐ paper towels
- ☐ a stirring rod or a spoon
- ☐ universal indicator papers and a scale
- ☐ vinegar

Section 2

- ☐ safety goggles
- ☐ an apron
- ☐ latex gloves
- ☐ eight clean plastic drinking glasses of the same shape and size
- ☐ a marking pen
- ☐ a ruler
- ☐ salt
- ☐ a spoon
- ☐ sugar



If you have access to the Internet, you may want to check out some of the links for this module ahead of time. Go to the following sites:

<http://www.mcgrawhill.ca/school/booksites/sciencefocus+9/student+resources/toc/index.php>

<http://www.ec.gc.ca/envhome.html>

Section 1

Environmental Quality

The natural beauty of clear, clean air and pristine water can be awe-inspiring. Unfortunately, chemical wastes may threaten both the environment and your health. Chemical wastes are a byproduct of the manufacture and use of chemical substances. What chemical substances do people make and use? That's what this section is about.

This section begins with an examination of the chemical nutrients required by your body. It then moves to the chemistry and consequences of growing the crops that provide these nutrients. An introduction to the acids and bases in your environment completes the section.



Lesson 1: Nutrients for Health and Growth



All matter—including plants—is composed of one or more chemicals. Your body is composed of chemicals and also needs them to grow and function. Such chemicals are called **nutrients**. Many nutrients that you need are found in plants.

***nutrient:** a chemical in food used for energy, growth, body building, or cell repair*

Turn to pages 178 and 179 of the textbook. Read the introduction to Topic 1, and also read “Take Two Pebbles . . .” Also study “Table 3.2” on page 180 to find out how elements are used in the human body.



***trace element:** a mineral that the body requires in an amount of less than 100 mg per day*

Ninety-nine percent of your body is formed from only six elements—oxygen, carbon, hydrogen, nitrogen, phosphorus, and sulfur. However, **trace elements** like copper play important roles in body functions and maintenance.

Even with a balanced diet, a person may develop a chemical imbalance and become unwell.

Turn to pages 180 and 181 of the textbook and read “A Balanced Approach.”



Going Further



These “Going Further” sections are for those of you who want to do extra in-depth work. There are lots of interesting topics to work on.



For more information about a balanced approach, check Canada’s Food Guide at this site:

http://www.hc-sc.gc.ca/hpfb-dgpsa/onpp-bppn/food_guide_rainbow_e.html



Obtain the advice of a doctor if you have any health concerns.

1. What element or vitamin might your body require in each of the following situations?
 - a. You’re having a problem regulating your metabolism. You’re too hot one minute and too cold and weak the next.
 - b. You seem to be retaining a lot of water.
 - c. You feel weak and tired all the time. Any form of exercise quickly forces you to breathe hard. **Hint:** For exercise, oxygen transport to muscles and energy production from sugar must be efficient.
 - d. You have been developing cavities lately, and your doctor says your bone density has decreased.
 - e. You have developed a goitre.
 - f. Your gums are bleeding, your teeth are falling out, and you find that you bruise very easily.
 - g. You have been eating space food—food for space travellers—and have developed an irregular heart rhythm when exerting yourself. **Hint:** See “Off the Wall” on page 180 of your textbook. An irregular heartbeat may involve faulty nerve activity.

organic compound:
generally, a compound whose molecules contain carbon atoms

inorganic compound:
generally, a compound whose molecules do not contain carbon atoms

active transport:
a process in which cells use energy to move nutrient molecules from areas of lower concentration to areas of higher concentration

nimby: someone who objects to the establishment in his or her neighbourhood of projects that are believed to be dangerous, unsightly, or otherwise undesirable

In this lesson, and in the rest of this course, you will be doing written work. You will sometimes be directed to an Assignment Booklet to do this written work. However, for the numbered questions in a Student Module Booklet, you should use a notebook set aside for Science 9. Also use the notebook to record results while doing science investigations.



2. Classify each of the following chemicals as either an **organic compound** or an **inorganic compound**.

- a. carbon dioxide (CO_2)
- b. propane (C_3H_8)
- c. silicon dioxide (SiO_2)
- d. glucose ($\text{C}_6\text{H}_{12}\text{O}_6$)
- e. sodium hydroxide (NaOH)

Organic and inorganic chemicals must be dispersed throughout your body as well as into and out of your cells. In an earlier science course you learned that diffusion, osmosis, and **active transport** move chemicals around.

3. Identify the method of transfer of the main substance in each of the following situations.
- a. During exercise, your muscle cells use large amounts of glucose. The glucose levels inside the cells become much higher than blood glucose levels.
 - b. Phosphorus and nitrogen concentrations in plant root hairs are higher than the concentrations found in adjacent soil.
 - c. A salt-water gargle can be used to kill bacteria in your mouth and throat. As you gargle, water moves out of the bacteria and causes the bacteria to die from dehydration.



Compare your responses with those in the Appendix on page 68.

Imagine helping to decide whether a major development will go ahead. You may have to convince a **nimby** about your point of view. Nimby is an acronym for “not in my backyard.” For example, a nimby would likely object to the development of a nearby incinerator, prison, or chemical plant.

Going Further

Are you a nimby or do you look at both sides of an issue?



Start thinking about the final “Going Further” of this module. It is based on the major project on page 256 of the textbook. You’ll deal with an issue—the construction of a chemical/fertilizer plant. Read “Looking Ahead” on page 177 of the textbook to get started. You’ll want your friends, your family, or your home instructor to participate in the project with you.



Remember, the “Going Further” items are for those of you who want to do extra in-depth work.

Getting to the Roots of Nutrition

Do you need another reason to appreciate plants? Maybe, if you’ve just finished mowing a big lawn. But remember that plants do the following. They

- photosynthesize by removing carbon dioxide from the atmosphere and releasing oxygen
- move ground water that would otherwise be lost back into the atmosphere
- filter pollutants out of the soil, water, and air
- stabilize and build soil
- provide shelter, food, and fibre to wild organisms and humans



Plants also extract billions of tonnes of sparsely spread minerals from the soil and subsoil every year. These minerals are essential to human health and survival.

Find out how plants play such an important role in obtaining minerals from earth.



Turn to pages 181 and 182 of the textbook and read “The Root Source.” Include “Table 3.3” in your reading.

generic:
characteristic of
a whole group or
class

4. Without plants, why would it be difficult to obtain many minerals from the soil?
5. Which element(s) has the highest concentration in each of the following?
 - a. Earth’s crust
 - b. a **generic** plant
 - c. a human body
6. The process of bioaccumulation of nutrients is important for healthy growth and maintenance. For bioaccumulation to occur, a substance must be absorbed from the environment faster than it is excreted by or broken down in the organism’s body.
 - a. Provide three examples of bioaccumulation in humans.
 - b. Are the concentrations of silicon similar to the concentrations of the substances mentioned in 6.a? What can you infer about silicon?
 - c. Make an inference about the human need for sulfur as compared to plants. Explain. What function does sulfur serve in your body?

substrate: the
base on which an
organism lives

*For example, soil
is the substrate of
most seed plants.*



7. What **substrate** do the following organisms absorb nutrients from? Refer to the related information in the textbook.
 - a. amoeba (page 4)
 - b. dandelions (page 8)
 - c. bacteria (page 18)
 - d. clover (page 22)
 - e. red algae (page 23)
 - f. mould (page 31)
 - g. lichens (page 231)



Compare your responses with those in the Appendix on page 69.

The “Pause and Reflect” on page 182 of the textbook asks you to make a prediction. You are to make a prediction about the effect of adding nitrogen as a fertilizer nutrient to the soil. Would this make more nitrogen available to humans eating the plants?

The next investigation allows you to test a related prediction: Does adding a fertilizer nutrient affect seed germination and growth?

Investigation 3A

The Effects of Fertilizer Nutrients on Seed Germination and Growth



Refer to the “Inquiry Investigation” on pages 183 and 184 of the textbook.

Read through the entire investigation. Take special note of the introductory information. You may make some changes to the steps of “Procedure.”

Tap water can be substituted for distilled water. Instead of using mass to measure the fertilizer, you may use volume—use 1 mL (approximately 1/4 teaspoon), 5 mL (1 teaspoon), 10 mL (2 teaspoons), and 15 mL (3 teaspoons) of fertilizer to make your solutions.



Turn to Assignment Booklet 3A. Complete questions 1 and 2 from Section 1.

Perform the steps of “Procedure.”

8. Answer question 3 of “Analyze” and questions 1 to 3 of “Conclude and Apply.”



Compare your responses with those in the Appendix on page 69.

end of investigation

Going Further



“Too much of a good thing is a bad thing!” Put this saying into an environmental chemistry perspective. Does this saying relate to some plant nutrients? Find out by trying the “Internet Connect” on page 184 of the textbook. Go to this site:

<http://www.mcgrawhill.ca/links/sciencefocus9>

Then press the “continue” button. Press “Expand All,” then scroll down to “Unit 3: Topic 1” and press the underlined “Internetconnect” for “Unit 3: Topic 1.” You’ll find information about plant nutrients as pollutants. You’ll understand how the saying “Too much of a good thing . . .” applies to phosphorus and nitrogen.



The Fertilization Dilemma



It's got to be good. Right? Fertilizer promotes plant growth. Plants provide essential nutrients. What could possibly be wrong with that? Check it out!



Turn to page 185 of the textbook and read “Commercial Fertilizers.” Then turn to page 186 and read “Issues Emerging from High Productivity.”

9. What natural process is imitated by adding nitrates, ammonia, and urea to soil?
10. How does nitrogen get into the soil?
11. What element does the mineral potash provide?
12. List a benefit relating to the large-scale use of artificial fertilizers.



Compare your responses with those in the Appendix on page 70.

Lawn fertilizers likely contain iron. This element helps plants photosynthesize. The presence of iron helps lawns stay a dark green colour. Find out more about fertilizers in “Going Further.”



Going Further

Refer to “Find Out Activity: An Analysis of Fertilizer Nitrogen” on page 185 of the textbook.

Use this activity to find out more about the materials that help make plants grow! The different forms of nitrogen make nitrogen available in “slow release” form.



13. Turn to page 186 of your textbook and answer questions 2 and 3 of “Topic 1 Review.”



Compare your responses with those in the Appendix on page 70.

Looking Back

In this lesson you learned a little bit about the chemistry of your body. You also found that the health of your body is heavily dependent on the plants in your environment. Plants are the source of several essential minerals. They provide you with a variety of organic compounds—vitamins, lipids, proteins, carbohydrates, and minerals. Fertilizers can be used to promote the growth of crops. However, they can become pollutants if they are used to excess.



Turn to Assignment Booklet 3A. Complete question 3 from Section 1.

Lesson 2: A Growing Concern



pesticide: a chemical applied to control pests

Perhaps you put fertilizer on your lawn. You might even use **pesticides**. Treating your lawn this way makes it healthy and green. Whether you treat a lawn this way is not really a life-or-death issue. Is it?

But growing high-yield crops is essential to supplying people with enough food. In addition to fertilizers, pesticides are often used to help grow high-yield crops.



Turn to page 187 of the textbook and read the introduction to the topic.

1. Name three kinds of pesticides—indicate which pest each controls.

The insecticide DDT is a white, crystalline solid with no odour or taste. It was widely used to control insects in agriculture and insects that carry diseases. Because of damage to wildlife, the use of DDT in Canada has been banned. But it is still widely used in some countries.



Turn to page 188 of the textbook and read “Issues Associated with the Use of DDT.”

2. Answer the question in “Pause and Reflect” on page 188.



Compare your responses with those in the Appendix on page 70.



Read “What’s Bugging You?” on page 192 of the textbook.

The use of pesticides is potentially hazardous. Minimizing the use of insecticides reduces the risk of harm to the environment. Are some countries better than others in avoiding the use of insecticides? Find out in the next “Going Further.”

Going Further

Are there patterns in the agricultural use of pesticides? Play with some statistics to see if you can identify patterns as you perform “Find Out Activity: The Use of Insecticides in Agriculture” on page 193 of the textbook.

You may find a spreadsheet to be helpful. The following chart set-up may help you compare ratios of insecticide use. Formulas are shown in Column D.

	A	B	C	D
1	Country	Insecticide Use (Mt)	Agricultural Area (1000 ha)	Ratio (Mt/100 ha)
2	Canada	3426	74500	=B2/C2
3	United States	103419	420250	=B3/C3
4				
5				
6				
7				
8				

Note: The symbol *Mt* stands for megatonne. The symbol *ha* stands for hectare. See “Skill Focus 4” on page 453 of the textbook for more information on units of measurement.

3. Consider the issue of DDT use. DDT is still used extensively in many developing nations. Many of the people who use it are struggling to survive! It is cheap, very effective, and is used to prevent serious insect-borne diseases and crop damage. Suppose you were

- a subsistence farmer
- barely able to feed your family
- unable to afford mosquito netting to protect your sleeping children from disease-carrying insects
- fighting to produce a crop under difficult conditions

Would you choose to use DDT to increase your chances of producing a reasonable crop and to protect your family from disease? What if you knew that many years down the road, a buildup of DDT in body tissue could have serious health implications? Or what if you knew that the DDT you use would circulate around the globe in the air and water and negatively affect people in other countries? Explain.

4. a. How many species of insects and mites were resistant to insecticides in 1940?
b. How many were resistant in 1990?



Compare your responses with those in the Appendix on page 71.

DDT was hailed as a “powerful insecticide” that was “harmless to humans” when it was first invented. Its “dark side” only became apparent a decade later. Could any of the many serious DDT consequences have been foreseen? One thing is certain—if human beings are aware of and learn from their experiences with DDT, it is less likely that the scenario will be repeated.

biomagnification:
the process
where chemicals
accumulate in the
tissues of
organisms along
the food chain

Biomagnification
is also called
bioaccumulation.

Biomagnification or bioaccumulation is the process responsible for the buildup of DDT to harmful levels.

DID YOU KNOW?



Some scientists make a distinction between the terms *biomagnification* and *bioaccumulation*. They use the term *biomagnification* for the increase of a chemical’s concentration along the food chain. *Bioaccumulation* is used for a related process—the increase in concentration of a chemical in a particular group of biological organisms over time.

The following investigation gives you the opportunity to become better acquainted with the DDT story.

Investigation 3B DDT in a Food Chain



Read the “Think and Link Investigation” on pages 189 to 191 of the textbook.

5. Name three non-target organisms affected by DDT.
6. Answer questions 1, 2, 3, 5, 7, and 9 from page 191.



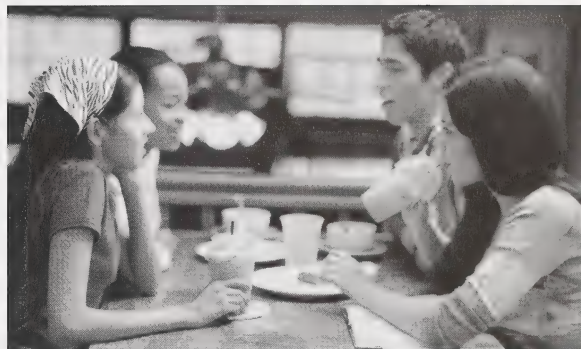
Compare your responses with those in the Appendix on page 71.

end of investigation



Turn to Assignment Booklet 3A. Complete questions 4 and 5 from Section 1.

Imagine going out with a group of friends. You want to wear your favourite perfume or cologne—but one person in the group is sensitive to perfume and cologne. Your friend suffers from shortness of breath and has difficulty breathing when cologne or perfume are in the air. You would probably think twice before deciding to put on perfume or cologne. You have **ethical** responsibilities.



ethical: relating to standards of right and wrong

legal: according to the law

As with cologne and perfume, you should think about others when applying insecticides. You not only have ethical responsibilities, but you also have **legal** ones.

Find out what your responsibilities to your neighbours are by “Going Further.”

Going Further

What are your legal and ethical responsibilities and rights regarding the use of insecticides on private property? Check the “Internet Connect” on page 193 of the textbook. Press “continue” and then “Expand All.” Note that the “Internet Connect” address should be

<http://www.mcgrawhill.ca/links/sciencefocus9>

Unit 3: Environmental Chemistry

Topic 1: A Hair-raising Dilemma

Topic 2: A Growing Concern

Cool Stuff To See And Do

Web Simulations

Internetconnect

Internetconnect

Study Tips And Tools

Study Quiz: A Growing Concern

Click the circled link shown above for information about the responsible use of insecticides.

There are safer pesticides being developed, but ongoing research is needed to minimize the negative consequences of pesticide use.

Read “Where to Now?” on page 196 of the textbook.



***organic agriculture:** the production of food with the use of feed or fertilizers of plant or animal origin and without the use of chemical fertilizers, growth stimulants, antibiotics, or pesticides*



Possibilities

Although pesticides are used widely, you and your family can decide on an alternative food supply—**organic agriculture**. “Going organic” will reduce your personal exposure to pesticides and may also reduce the spread of pesticides in the environment.

Turn to “Decision-Making Investigation 3C: Organic Agriculture” on pages 194 and 195 of the textbook. Read “How Can Science Help?” and “Think About It.” Also read “Did You Know?” and “Word Connect.”

7. Answer the following questions.

- a. Organic agriculture uses _____ to minimize environmental damage and optimize productivity.
 - b. What does the development and testing of new pesticides require?
8. Think about this question. Is a natural chemical necessarily any less toxic than a synthetic chemical? Explain.
9. Try to give two alternatives to using agricultural chemicals. You may have to think back to previous science courses.



Compare your responses with those in the Appendix on page 72.

10. Turn to page 196 of your textbook and answer questions 3, 4, and 6 of “Topic 2 Review.”



Compare your responses with those in the Appendix on page 73.

Looking Back

In this lesson you explored ways of protecting crops from the damage of pests. You used a case study of DDT. You looked at mechanisms for the transfer of pesticides through the food chain and the environment, and you assessed some of the financial, environmental, and health costs of pesticide use. Finally, you considered organic agriculture as an alternative for food production.



Turn to Assignment Booklet 3A. Complete questions 6 and 7 from Section 1.

Lesson 3: Effects of Acids and Bases

In Module 2 you learned that corrosives are chemicals that break down other substances through chemical action. You probably think of **acids** as being corrosive—and many are corrosive. But there are many acids and their opposites—**bases**—that you experience safely in the world around you.



***acid:** a substance soluble in water with a pH of less than 7*

An acid turns blue vegetable colours to red colours.

***base:** a substance with a pH of more than 7*

A base can be neutralized by an acid.

Turn to page 197 of the textbook and read the introduction to the topic.

1. Match the following. Write down either *A* or *B* to the left of each definition.

- | | |
|--|---------|
| ___ a. tastes sour | A. acid |
| ___ b. feels slippery | B. base |
| ___ c. tastes bitter | |
| ___ d. causes burning sensation in muscles | |

Turn to page 197 of the textbook and read “Acids and Bases.” Find out which acids and bases are key components in familiar products.

2. Match the following.

- | | |
|---|-----------------------|
| ___ a. antacid tablets | A. aluminum hydroxide |
| ___ b. household and industrial strength cleaners | B. phosphoric acid |
| ___ c. a strong acidic electrolyte in car batteries | C. sodium hydroxide |
| ___ d. a tangy flavour in food | D. sulfuric acid |

The colour change of a **chemical indicator** can show you how acidic or basic a liquid is. The reading on a pH meter scale—the **pH scale**—can also show you this information in a quantitative way. The next reading will explain this.

***chemical indicator:** a substance containing a chemical that changes colour according to acidity or alkalinity*

***pH scale:** a quantitative scale that indicates how acidic or alkaline a solution is*



Turn to pages 198 and 199 of the textbook and read “The Observable Properties of Acids and Bases” and “pH: A Powerful Scale.”

3. Suppose red litmus paper turns blue in solution 1 and blue litmus paper turns red in solution 2. Neither one changes colour in solution 3. What could you infer about solutions 1, 2, and 3?
4. List the following substances according to their pH, going from lowest to highest pH:
 - baking soda
 - car battery acid
 - drain cleaner
 - household ammonia
 - human blood
 - normal rain



Compare your responses with those in the Appendix on page 73.

In the next investigation you’ll use cabbage juice as a chemical indicator. The cabbage juice may be stinky, but it works. Try to get your family and friends to help. Ask your home instructor or teacher to supervise you and help with the investigation.

Only use materials approved by your adult supervisor. Perform the investigation under the direct supervision of your home instructor or teacher.



Investigation 3D The pH of Common Acids and Bases

Refer to the “Inquiry Investigation” on pages 201 to 203 of the textbook.

Read the entire investigation. Take careful note of the safety precautions. Wear latex gloves, a protective apron, and safety goggles.



The red cabbage juice solution is a universal pH indicator. It is purple when neutral, and it ranges through beautiful golds and greens (basic), and blues and reds (acidic) as the pH of the solution changes.



For a stronger, more effective solution of cabbage juice indicator, cover the cut-up cabbage with water. Then have your home instructor boil it for about an hour. Allow the solution to cool before use. When preparing your cabbage juice indicator, do not use an aluminum pot—the cabbage juice reacts with aluminum to release a very stinky sulfur compound. Instead of a rich purple solution, you get an ugly brown solution (another new chemical) that does not work very well as an indicator.



Under the direct supervision of your home instructor, boil the cabbage to make extra solution for additional testing. Anything you test must be water-soluble. Be careful—strong acids and bases are very corrosive. Wear your safety equipment.

Red cabbage juice stains. It is a good idea to perform this investigation in a sink or cake pan to catch spills. Use clear, colourless containers or white soup or dessert bowls instead of test tubes. Be sure to wash the container each time before you add the cabbage juice indicator.

Try your own neutralization reaction. Dissolve a little baking soda into about 100 mL of indicator solution. Add some vinegar to 100 mL of indicator in a different container. Note the colours. Slowly pour the two solutions together in a larger container placed in a sink or a cake pan. You can then continue to add small amounts of baking soda or vinegar. Remember that a neutral acidity is indicated by the original purple colour. The acid and base must be present in the correct proportions for the solution to become neutral.

You can use

- any antacid or baking soda instead of milk of magnesia
- a few grains of instant coffee instead of 10 mL of black coffee
- water from the tap instead of distilled water and rainwater

Whenever possible, choose clear, colourless solutions to test.



Household ammonia is corrosive. Have your teacher or home instructor prepare the dilute ammonia solution for step 1 of “Procedure” in “Part 2: Breath Check.”

Only perform the entire investigation (plus some tests of your own) under the direct supervision of your home instructor or teacher.

5.
 - a. What is the range of the pH indicator paper you were using?
 - b. Which indicator provided more accurate results? Explain.
6. Answer question 1 from “Analyze” and question 3 from “Conclude and Apply.”



Compare your responses with those in the Appendix on page 74.

end of investigation

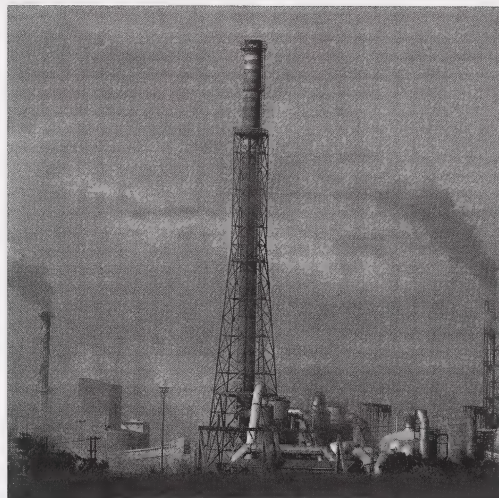


To get a more in-depth look at acid-base reactions, watch the segment “Acids and Bases” on the *Science 9 Multimedia* CD.

Acid Precipitation

Have you ever wondered where all the emissions go after they leave factory towers?

It turns out that what goes up must come down. But while up there, “it” just might be up to some chemical “mischief.” This is the case with the formation of acid precipitation. Sulfur and nitrogen oxides are released by certain industries. Carbon dioxide escapes when fossil fuels are burned. These emissions react chemically with water in the atmosphere to produce acids. The result is acid precipitation.



Turn to pages 204 and 205 of the textbook and read “Acid Precipitation—a Global Concern.” Also read the margin items.

Acid snow can be particularly bad because snow accumulates over the winter. The spring thaw releases the buildup. This causes a large influx of acid into ground water and surface water systems. This “acid shock” occurs just as organisms are laying eggs. Fresh eggs are vulnerable to acidity. In ground water the acid shock destroys the tiny root hairs of plants, which are vital for water and nutrient absorption. The high acid concentration also kills important bacteria.

7. Where does at least 50% of the acid precipitation in eastern Canada come from?

The limestone-based soils of central and southern Alberta act as a natural buffer to quickly neutralize acids.

Provinces on the inert granite of the Canadian Shield are not so fortunate. Acidification has killed many of the tapped sugar maple trees. It has eliminated most of the plants and animals from many lakes. Scientists are now experimenting with techniques to decrease the effects of acid precipitation.



Turn to page 207 of the textbook. Read the entire page.

8. Acid rain affects soil and even rock.
- Think back to Module 5: Planet Earth, from Science 7 or check a dictionary. What was marble formed from? Why would marble statues be affected by acid rain?
 - How does acid precipitation affect the soil?
9. Normal precipitation is only slightly acidic. A portion of precipitation runs into streams and lakes.
- Why does normal rainwater have a pH of 5.6 (rather than 7)?
 - Acid fog in Los Angeles has reached pH levels as low as _____, which is _____ times more acidic than normal rain.
 - How can an acidified lake be returned to normal?



Compare your responses with those in the Appendix on page 75.

Fish populations are affected when lakes become acidified. In the next investigation you will gain insight into how pH affects living things. You will examine the population data of yeast cultures that live in water at various pH levels.

If you have access to a teacher-supervised laboratory, follow the procedure of the investigation.

If you don't have access to a supervised laboratory, use the table of observations given to you in this investigation.



Investigation 3E The Effect of pH on a Population

Refer to the "Inquiry Investigation" on page 206 of the textbook.

One group of students used a drop of liquid from each test tube as samples. They made wet mount slides to do a count of yeast cells under a microscope. The students used the cell counts in the samples as relative population densities of yeast at the different pH levels.



Their results were as follows.

The Population of Yeast at Various pH Levels After 24 Hours	
Test Tube pH	Relative Yeast Population Density
2	4
3	17
4	36
5	74
6	85
7	87
8	79



Read the entire investigation. Take careful note of all safety precautions. Only follow the steps of “Procedure” under the direct supervision of your teacher or home instructor. You can use vinegar as your acid and a baking soda solution as your base.

10. Answer question 1 from “Analyze” and questions 2 and 3 from “Conclude and Apply.” You may base your answers on the results given in the data table on this page.

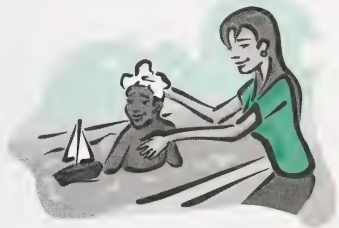


Compare your responses with those in the Appendix on page 75.

end of investigation

Have you heard of people rinsing their hair with vinegar after washing it?

This idea grew from a time when shampoos were very alkaline. The acidity of the vinegar was designed to neutralize any shampoo left in the hair. Most pH-balanced shampoos are now fairly gentle and don't require an acid rinse. That's good, because the acidity of too much vinegar can harm people's hair.



In the neutralization of acids and bases, just the right amounts of each must be involved. Adding too much of one or the other makes you overshoot the neutralization point. With **titration**, a solution can be added drop by drop to properly hit the neutralization point.

titration: the precise addition of a solution in a burette—or a graduated glass tube—into a measured volume of a sample solution

Play the *Science 9 Multimedia* CD on a computer. Once the first screen appears on your computer, select “Titration.” This multimedia segment shows a titration procedure that, like the next investigation, uses bromothymol blue as a pH indicator.

Your food starts to break down into nutrients due to the corrosive action of hydrochloric acid in your stomach. The hydrochloric acid has a low pH (high acidity) and is quite concentrated. The lining of your stomach is specially adapted to prevent hydrochloric acid from digesting it along with your food. But sometimes “acid indigestion” can get the best of you. You can swallow a weak base to provide relief.

In the next investigation you can see how an acid and a base can be combined in neutralization, and you will also find out how relief from acid indigestion is connected to acid-base neutralization.

Investigation 3F Drop-by-Drop Neutralization

Refer to the “Inquiry Investigation” on page 208 of the textbook.

Bromothymol blue is a pH indicator that turns yellow in an acid solution and remains blue in a neutral or basic solution. For this investigation, the indicator is first placed in an alkaline solution—this turns the solution blue.

Hydrochloric acid is added drop-by-drop until the indicator turns yellow. At this point, the solution has just changed from being neutral to being acidic. This point can be viewed as the neutralization point. All the drops released from the dropper will be the same size. The technique of adding a chemical drop by drop until a change occurs is referred to as *titration*.



Read “Investigation 3F”; then use the following representative data in the column “Number of Drops . . .” to answer the questions.

Acid-Base Titration			
Solution	pH of Alkaline Solution	Relative Strength Rating (Strong, Medium, Weak)	Number of Drops of Acid Required to Neutralize the Base
sodium hydroxide (drain cleaner)			25
baking soda			5
antacid (e.g., milk of magnesia)			15

- Complete the table. **Hint:** Refer to “Figure 3.9” on pages 198 and 199 of the textbook for levels of pH and relative strength.
- Answer “Analyze” question 2 on page 208 of the textbook. **Hint:** You are to look for a ratio.



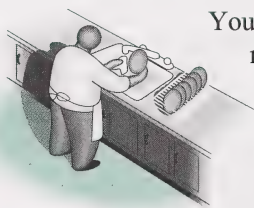
Compare your responses with those in the Appendix on page 76.

end of investigation



Turn to Assignment Booklet 3A. Complete question 8 from Section 1.

Cleaning Up with Chemistry



Your chores probably include some household cleaning. The next reading from the textbook focuses on “scrubbing” up of another kind!

Turn to pages 209 to 211 of the textbook and read “Using Chemistry to Control Harmful Emissions” and “Scrub Those Cares Away.”



13. There are solutions to the threat of acid precipitation. Fortunately, many of Alberta's soils and water systems are naturally buffered against acid precipitation.
- Why is liming only a temporary solution to acid precipitation?
 - List two ways to remove oxides from car and factory emissions.
 - Natural buffering protects Alberta. Give another reason why Alberta is unlikely to have an acid precipitation problem.



Compare your responses with those in the Appendix on page 76.



14. Turn to page 211 of your textbook and answer questions 1 to 5 of "Topic 3 Review."



Compare your responses with those in the Appendix on page 77.

Looking Back

In this lesson you studied acid-base chemistry in the context of the environment. You developed a basic understanding of pH, measurement and pH indicators, and the interaction of acids and bases. A look at a few techniques and technologies designed to reduce the problem of acid precipitation completed the lesson.

Lesson 4: Wrap-up

Review the concepts you have learned by completing the following questions.

Turn to page 212 of your textbook and answer question 1 and questions 3 to 5 of "Wrap-up: Topics 1 to 3."



Check your answers with your teacher or home instructor.

Section 1 Conclusion



Natural beauty can be inspiring. But what would these flowers look like if they had been harmed by acid precipitation or by another chemical waste? Would they even be alive? When people cause a problem, it's up to them to find solutions. What are the major tools in the struggle to maintain a healthy global, local, and personal environment? The tools are awareness, motivation, and scientific knowledge.

Chemical wastes are a by-product of the manufacture and use of chemical substances. You studied these chemical substances and their associated wastes in this section.

You began with an examination of the chemical nutrients required by your body. You then moved to the chemistry and consequences of growing the crops that provide those nutrients. Finally, you focused on the role of acids and bases in the environment.



Turn to Assignment Booklet 3A. Complete questions 9 to 14 from Section 1.

Section 2

The Problem of Pollution

Have you seen clouds of material billowing out of emission towers? Are the emissions harmful substances or just water vapour? Will plants and animals be harmed?

Materials that cause harm to living organisms are called pollutants.

Some substances released into the environment are considered to be pollutants. In this section you will find out how chemistry is used to assess what substances are pollutants. You will also learn about pollution sources, toxicity, risk assessment, environmental monitoring, and water quality. You will then apply this knowledge to decision making, and you will deal with issues related to pollution and waste management.



Lesson 1: How Much Is Too Much?



In pioneer days, people living on the prairies didn't have running water. Water for a bath was likely hauled from an outside well and heated on a wood-burning stove. Filling the tub with water was not a matter of just turning on a faucet—it was a real chore.

pollutant: a material or form of energy that will cause harm to living organisms

pollution: any alteration of the environment that produces a condition harmful to living things

The act of contaminating the environment with pollutants is pollution.

Once the bathtub was filled with warm water, it was not unusual to have several members of the family share the water—one after the other. You'd be lucky to be the first in line. Then you would have the cleanest water. The next person would still have clean water. The next person would have fairly clean water. If the family was large, the last person might question the water's cleanliness.

The sharing of bath water leads to this question. How much mud, dust, or grime in the water is too much? You'd certainly think about this if the family dog somehow got in the tub ahead of you.

A similar question could be asked about a **pollutant** in an environment. A very small amount may not be detectable. But when a pollutant builds up due to ongoing **pollution**, there comes a point when there is too much. When is that level reached? It may be too much before it even becomes visible.

Turn to page 213 of the textbook and read the topic introduction.

What if the standard for pollution is based on detection? The next investigation shows that even a standard based on detection may not give a clear-cut guide.



Investigation 3G Where Does Pollution Begin?



Read through the “Inquiry Investigation” on pages 214 and 215 of the textbook.

In “Part 1” you will prepare a series of salt solutions that are diluted by a factor of 10 each time. The steps of “Procedure” work best with drinking glasses that have sides that go straight up and down. In “Part 2” you will use a taste test to see what the minimum dilution is that a person can taste. In “Part 3” you will do everything again, but with water.

Follow the steps of “Procedure” for all three parts of the investigation. Sign up your family, friends, or home instructor as test subjects.



1. Answer questions 1 and 2 from “Analyze” and question 4 of “Conclude and Apply.”



Compare your responses with those in the Appendix on page 77.

end of investigation



Find out how to express concentrations of substances in a quantitative way. Read “How Much Is That?” from page 216 of the textbook.

2. Calculate the salt concentration (in ppm) when you have dissolved 10 mg of salt into 250 g of water (250 mL of water has a mass of 250 g).



Compare your responses with those in the Appendix on page 78.

Note: When 1 mg of a solid is dissolved in 1 L of water, its concentration is 1 ppm. In other words, 1 ppm of a solid in water can be written as 1 mg/L.



Can the water be unsafe for people yet safe for ducks? Or is this a case of ignorance is bliss?



Turn to page 217 of the textbook and read “The Danger Is in the Dose.” Find out the possible effects of toxic substances.

3. You are the water manager for a large North American city. You will be processing one billion kg of drinking water over a certain time period. You have tested the water and found that it contains 0.05 ppb of mercury, 1.3 ppb of arsenic, and 9.4 ppb of lead.
 - a. What mass of each mineral is in the water that the manager is processing over the time period?
 - b. Is this water safe to drink as far as the mineral content is concerned? Explain.

Going Further

How safe are you? What is the quality of water like in Alberta and Canada? Follow the “Internet Connect” on page 217 of the textbook to find out. When you are on the site, click “continue” and navigate to the circled site.



Unit 3: Environmental Chemistry

➤ Topic 1: A Hair-raising Dilemma

➤ Topic 2: A Growing Concern

➤ Topic 3: How Do You Spell Relief?

➤ Topic 4: How Much Is Too Much?

➤ Cool Stuff To See And Do

➤ Internetconnect

Internetconnect

➤ Study Tips And Tools

Risk Evaluation—Costs and Benefits

People wear high heels to look fashionable. Yet, high heels can lead to lower back pain, aching feet and legs, and even clawed toes. Good advice might be to wear them only for special occasions. There are both costs and benefits to wearing high heels. That puts people in a bind, doesn't it?



Choosing to use chemicals in the environment or as medicine also puts people in a bind. Again, costs go along with desired benefits to make things complicated.

DID YOU KNOW?

?

Some substances can be both medicinal and toxic—depending on the dosage. *Coumadin* is the medical name for *warfarin*, a chemical commonly used to poison rodents. This chemical is a blood thinner that causes severe internal bleeding when used as a pesticide. As a medicine, coumadin is used in low concentrations to provide protection against strokes and heart attacks.

Coumadin levels in the blood are closely monitored. Doctors know where the benefit ends and the toxicity begins. The oral dosage is adjusted accordingly.

Read “Lethal Dose 50” on page 218 of the textbook.

4. Do the following chemical concentrations, measured within the human body, exceed the LD50 dose?
 - a. nicotine—0.75 ppm
 - b. tetanus toxin A—0.0000055 ppm

Turn to page 219 of the textbook and read “An Acceptable Risk?” and “Thalidomide Issue.”

5. Why is a waiting period important before a new chemical is approved for use?

6. People take potentially harmful substances voluntarily.
- a. For many people, drinking coffee is a(n) _____ risk.
 - b. _____ chemical has the potential to be harmful, depending on _____.



Compare your responses with those in the Appendix on page 78.

Chemicals support modern lifestyles—some chemicals are essential. Chlorine is one of these essential chemicals, as the people of Walkerton, Ontario found out in May and June of 2000. At that time, seven people died in Walkerton after drinking infected water from the town's water supply, and half of the town's people got sick. The water was infected with *E. coli* bacteria carried from upstream feedlots. Proper chlorination would have killed the pathogen.



Yet, individuals and organizations must consider many factors before using a potentially toxic chemical. What chemical is most appropriate for the purpose? What financial costs are involved? When should it be used? In what quantities? Where? How should it be used? How might it affect people, other organisms, and the environment in the short-term? What about the long-term? At what levels is the chemical safe to use? Could it react with another chemical in the environment to create a toxic substance? What are its breakdown products? Evaluating the risks associated with chemicals requires a great deal of knowledge and experience.

Think carefully about the following balance-the-risks example.

Chlorine is used to kill bacteria in water. Chlorine combines with organic matter to form a proven carcinogen called *trihalomethane* (THM). It has been estimated that three cancer deaths per million people would result each year if everyone in the United States spent a lifetime drinking water with a concentration of 100 ppb of THM. Government officials in Peru used THM as the reason for shutting down water chlorinating systems throughout the country. But with no chlorine in the water, a cholera epidemic spread throughout Peru and killed more than 2000 people—that was 125 deaths per million people in only 10 months. It seems the choice to drop chlorination did not balance the risks, because the results were deadly.

DID YOU KNOW?



Buying drinking water that is both unchlorinated and bottled is a very common practice. Pathogens can grow in

- poorly maintained water dispensers
- previously opened water bottles
- water stored in improperly cleaned water bottles

It's hard to get everyone to agree about this question, but how much is too much? Even with objective data about LD50 levels and acceptable ppb concentrations, there is still a subjective component to answering the question. People not only interpret the data differently, but they differ on how much risk they are comfortable with. And people put different values on the costs and benefits.

Turn to page 220 of the textbook and read "The Evaluation of Risk."

7. Turn to page 221 of your textbook and answer questions 4 and 5 of "Topic 4 Review."



Compare your responses with those in the Appendix on page 79.

Looking Back

In this lesson you looked at the level at which a substance causes pollution. You found out how to express very small concentrations of toxins in ppm. You used LD50 to quantify the toxicity of substances. Then you considered perspectives related to evaluating risks that are associated with the use of chemical substances.



Turn to Assignment Booklet 3B. Complete questions 1 to 3 from Section 2.

Lesson 2: Water Quality

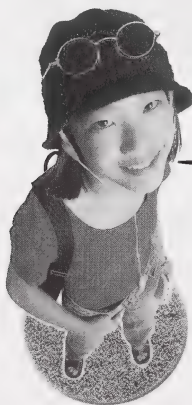
Is this fish safe to eat? It lives, breathes, and eats in the water. The same can be said for most of the organisms it eats. But water in the environment may become polluted. Pollutants in the water could affect the food web of this fish—and the person at the other end of the fishing line.

This lesson focuses on water quality. There are pollutants that affect this quality. You will apply techniques used to measure and monitor such pollutants.

Refer to pages 222 and 223 of the textbook. One student, Mai, made this summary of these pages.



persistent:
*tending to
accumulate in the
environment and
to break down
very slowly, if at
all*



The human population has grown immensely. Along with this growth came a lifestyle that exploited the environment more than it previously had. The result is that humans produce wastes that accumulate to harmful levels. The **persistent** pollutants stay around the longest. When wastes accumulate, they tend to end up in bodies of water. Samples of water can be tested for the presence of pollutants.

Read pages 222 and 223 of the textbook for yourself. See if—somewhere in the textbook reading—you can find the ideas from Mai's summary.

Phosphates and nitrates are naturally occurring chemicals that are essential to plant growth. Phosphates and nitrates are pollutants if they come from sewage run-off or agricultural run-off.

algal bloom:
*a large increase in
the algae
population due to
increased levels
of nutrients in a
water system*

At harmful levels, phosphates and nitrates in water lead to **algal blooms**. As the result of such a population explosion, a large number of algae die. Decomposers flourish on the dead algae and use up oxygen. Therefore, decomposition leads to low oxygen levels in the water. Oxygen is critical to aquatic organisms—notably fish.

The levels of dissolved phosphates, nitrates, and oxygen are related. The levels of these chemicals, along with the level of carbon dioxide, are good indicators of water quality.



Read the paragraph on page 225 of the textbook for more information on the significance of dissolved phosphates, nitrates, and oxygen in bodies of water.

Although dissolved phosphates and nitrates cannot be observed directly, there are chemical tests to determine their presence.

Investigation 3H Measuring the Amount of Phosphates and Nitrates in a Water Supply



Refer to the “Inquiry Investigation” on pages 225 to 227. Don’t physically carry out the investigation—you are only to become acquainted with the chemical tests of the investigation.

Take special note of the “Apparatus” and “Materials.”

1. Read the procedure of “Part 1: Testing for Phosphates.”
 - a. Write down the letters *A* to *D* to show in which order the following steps should be done.
 - A. Add dilute ammonium hydroxide to the water samples.
 - B. Add magnesium sulfate solution to each test tube.
 - C. Let the test tubes and their contents stand for five minutes.
 - D. Place a water sample in each marked test tube.
 - b. How do you know if a water sample contains phosphate?

This test for phosphate is a qualitative test. It is simply used to show that phosphate is or isn’t present. This test does not give the concentration.

- c. Suggest a way that you might be able to obtain a quantitative measure for samples by using this phosphate-testing technique.



Compare your responses with those in the Appendix on page 79.



Read “Procedure” of “Part 2: Testing for Nitrates” on page 226 of the textbook. Note that the procedure is based on the use of a specific test kit.

Look at the photograph on page 227 that shows the colour scale for nitrates. For this test, a chemical that reacts with nitrates to produce a new pink chemical is added to each water sample. The higher the concentration of nitrates, the pinker the solution becomes. Look carefully. You'll see the numbers on the scale range are 0, 10, 20, and so on up to 70.

2. According to the "Procedure" in "Part 2: Testing for Nitrates," the test is first done to distilled water. Then it is done to actual water samples you have collected. In what order should the following steps be done when testing a sample of water you have collected? Show the order of the steps by listing the letters in correct order from *A* to *H*.
- A. Add a nitrate-reducing reagent to the test tube.
 - B. Add the mixed acid reagent to the test tube.
 - C. Cap the test tube and invert it over and over for one minute.
 - D. Cap the test tube and turn it upside-down several times.
 - E. Complete the nitrate-N comparator steps.
 - F. Let the test tube stand for ten minutes.
 - G. Let the test tube stand for two minutes.
 - H. Place a portion of the water sample into a test tube.

3. Answer question 3 from "Analyze" on page 227 of the textbook.

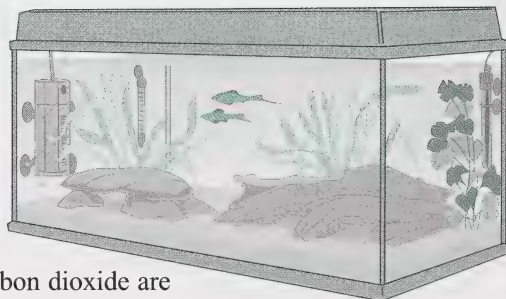


Compare your responses with those in the Appendix on page 79.

----- end of investigation

You may have seen air bubbling through water in an aquarium. This was due to air being pumped into the water. The air going through the water keeps up the dissolved oxygen level in the water. The dissolved oxygen is needed by the fish.

Both levels of dissolved oxygen and carbon dioxide are important aspects of water quality.



Fortunately, there are also chemical tests available to determine the presence of oxygen and carbon dioxide.

Investigation 31 Testing Water Quality



Refer to the “Inquiry Investigation” on pages 228 and 229 of the textbook. Don’t physically carry out the investigation—you are only to become familiar with the methods used in the chemical testing.

The tests for dissolved oxygen and dissolved carbon dioxide in the textbook use a titration technique to produce quantitative data. First, one or more chemicals are added to the sample to detect the presence of the gas and create a coloured solution. If the dissolved gas is present, another chemical is dripped in, or titrated, until the colour of the sample changes.

The number of drops required to create this change is used to calculate the amount of dissolved gas in the sample.

Read “Procedure” from “Part 1: Dissolved Oxygen” and also read “Procedure” from “Part 2: Dissolved Carbon Dioxide.”

4. How do you know if the water sample contains the following items?
 - a. dissolved oxygen
 - b. dissolved carbon dioxide
5. When testing for dissolved oxygen, a student recorded 16 drops of sodium thiosulfate as the amount needed to make the sample a clear colour. What was the dissolved oxygen content of the sample? **Hint:** Question 1 of “Analyze” shows how to do the calculation.
6. When testing for dissolved carbon dioxide, a student recorded three drops of sodium hydroxide needed to make the sample a pink colour. Determine the dissolved carbon dioxide content of the sample. **Hint:** Question 2 of “Analyze” tells how to do the calculation.



Compare your responses with those in the Appendix on page 79.

end of investigation

DID YOU KNOW?

?

Here's a memory clue for interpreting dissolved oxygen levels in a natural water system.

8 (ppm or mg/L) is great, 4 is poor, and 2 is terrible.

At 8 ppm, most aquatic organisms can survive and reproduce. At 4 ppm, many species have difficulty living and reproducing. At 2 ppm, few species can survive.

In one chemical analysis of water samples, the following data were obtained.

Water Quality Testing Results						
Tests Performed	Tap Water	Distilled Water	Fertilizer Water	Pond Water	Aquarium Water	Dishwashing Detergent Water
pH	6.9	7.0	8.8	8.2	7.4	7.6
chlorine (ppm)	0.1	0.0	0.1	0.0	0.0	0.1
dissolved oxygen (ppm)	8.0	0.9	8.0	4.5	12.6	8.0
dissolved carbon dioxide (ppm)	5.0	0.7	5.0	8.7	9.2	5.0
phosphates (ppm)	1.4	0.0	47.0	14.3	0.0	3.1
nitrates (ppm)	0.5	0.0	62.9	12.5	1.4	0.8

7. Draw one or more inferences from the chlorine test results.
8. Draw one or more inferences from the concentrations of dissolved oxygen and dissolved carbon dioxide in the aquarium, as compared to the other water samples. Explain.



9. Draw one or more inferences from the dissolved oxygen level of the pond water. Explain.
10. Answer “Analyze” questions 1 and 2 and “Conclude and Apply” question 3 on page 229 of the textbook. Use the following information to answer the questions. Assume that sample X (cold pond water) required ten drops of sodium thiosulfate and two drops of sodium hydroxide. Sample Y (previously hot pond water) required two drops of sodium thiosulfate and one drop of sodium hydroxide.
11. Relate the dissolved oxygen concentrations of samples X and Y to their abilities to support life.
12. The power plant at Wabamun, Alberta continually releases a large volume of heated water into nearby Lake Wabamun. What effect could this have on the fish in the lake? Explain.
13. The eggs of certain species of trout require high oxygen levels to survive and develop. Suggest a specific area of Alberta that could meet their needs. Explain.



Compare your responses with those in the Appendix on page 80.



Turn to Assignment Booklet 3B. Complete questions 4 to 6 from Section 2.

Bioindicators: Indirect Water Quality Assessment



Remember going to the local swimming pool? It probably had a sign reminding swimmers to shower before entering the pool. Showering not only helps maintain the water quality, but it minimizes pollution.

biological indicator: a living organism whose state is indicative of conditions in a particular environment

The water quality in natural bodies of water can be affected by pollution as well. You have seen that chemical tests can be used to assess water quality in a direct way. You can also assess water indirectly. Just look at what lives in the water and how well it lives. It's as if certain organisms respond to a sign reading "Pool Closed" when the water is bad. Such organisms serve as **biological indicators**.



We studied a variety of biological indicator species in Science 7.

Yes, you did. That's a long time ago, so you may need a review. In the next reading you will look at some of these species again.



Turn to pages 230 and 231 in the textbook and read "Biological Indicators of Water Quality."

14. a. What chemical factor does water pollution often affect?
b. What biotic factor does water pollution usually affect?
c. Name a biotic acid-base indicator used to warn about air pollution.
Hint: Refer to "Pause and Reflect" on page 231.
15. Can you consider trout and catfish to be macroinvertebrate bioindicators? Explain.



16. Refer to "Figure 3.22" on page 230 of the textbook.
a. In the "Decomposition Zone," why does the biochemical oxygen demand suddenly increase?
b. Which two zones are characterized by the same types of animals?
c. Are the zones distinct areas or do they gradually blend into each other? Explain.

17. Study “Table 3.5” on page 231. In this table, water quality is rated by oxygen concentration. The invertebrates listed in the “Poor Quality” or “Moderate Quality” columns can be found in better quality water. However, the populations of invertebrates found in the “Good Quality” column quickly decline or die out at about 6 ppm. Organisms in the “Moderate Quality” column will have mostly disappeared by 4 ppm. Very few organisms can survive in water with less than 2 ppm of oxygen.
- a. Water sample *M* has an oxygen concentration of 9.4. Does this prove that it is good quality water? Explain.
 - b. Use your interactions of species knowledge to predict what will happen if the oxygen concentration in a pond falls from 9 to 6.
 - c. Estimate the oxygen levels in each sample by looking at the number of freshwater invertebrates in the following samples.
 - (i) Site A sample: 3 midges, 3 caddis flies, 1 damsel fly, 1 leech
 - (ii) Site B sample: 4 crane flies, 5 dragonflies, 1 stonefly, 3 blackflies
 - (iii) Site C sample: 1 gilled snail, 5 mayflies, 2 crane flies, 1 crayfish
 - (iv) Site D sample: 3 midges, 4 leeches, 1 worm, 1 dragonfly



Compare your responses with those in the Appendix on page 81.

point source: a specific location where pollution originates

Pollution that comes from a **point source** is easier to control.

Turn to page 234 of the textbook and read “Point Versus Non-point Sources.”

18. Classify the following pollution sources as point sources or **non-point sources**.

- a. the feedlot located on Merry Brook, 10 km upstream from the town of Smithville
- b. feedlots and pastures located throughout the Slave Lake River Basin

non-point source: a source of pollution in which pollutants are diffuse and don't originate from a specific location



Compare your responses with those in the Appendix on page 82.

Going Further



Refer to “Decision-Making Investigation 3J: Assessing Water Quality with Macroinvertebrates” on pages 232 and 233 of the textbook.

Get some hands-on experience. Obtain an identification guide or key to freshwater invertebrates, and then assess the water quality in your area.



Use a search engine to locate Canadian sites on freshwater invertebrates. Search with the words *aquatic macroinvertebrates*.

19. Turn to page 235 of your textbook and answer question 3 of “Topic 5 Review.”



Compare your responses with those in the Appendix on page 82.

Looking Back

These fish lived, breathed, and ate in the water. So did most of the organisms the fish ate. Water quality was vitally important to these organisms.

In this lesson you conducted investigations to detect pollutants in water and to assess water quality. You used both chemical tests and biological indicators.



Turn to Assignment Booklet 3B. Complete question 7 from Section 2.

Lesson 3: Waste in the Environment

Nice garbage dump, right? Wrong. It's a littered beach! Litter is one of the most obvious wastes that people leave in the environment. Everyone produces waste. Unfortunately, "just throwing it away" doesn't mean it stays away.

In this lesson you will consider some of the effects of consumer and industrial waste on the local and global environment. You will study the distribution of pollutants through soil, water, and the air. Personal and large-scale waste reduction and management wraps up the lesson.

Turn to page 236 of the textbook and read the information on that page.



A nimby would oppose the establishment of a landfill or a sewage treatment plant in his or her neighbourhood. This person objects, knowing full well that the facility is necessary for his or her wastes and everyone else's garbage. The nimby may be unwilling to face up to the responsibilities that go along with his or her production of waste materials.

1. Have you been like such a nimby in some ways? Explain your answer in a paragraph.



Compare your responses with those in the Appendix on page 82.



Is releasing pollutants from a high tower the answer? In a way, the answer is blowing in the wind.

Pollutants can travel from one continent to another. Rivers, currents in the atmosphere, and ocean currents transfer materials great distances.



Turn to page 237 of the textbook. Read “Blowing in the Wind.”

2. Pollutants move huge distances away from where they were produced.
 - a. How long does it take for Russian pollutants to cross the Arctic to Canada?
 - b. How do Inuit people living in the high Arctic, and away from industrialized regions, end up with high levels of PCBs in their blood?

Many pollutants do their harm only when they accumulate near Earth’s surface. Chlorofluorocarbons cause damage from way up in the atmosphere beyond the reach of even the highest-flying birds.

Going Further

Did you know that the Ruppell’s griffon vulture holds the record for the highest-flying bird? One of these vultures was sucked into a jet engine at an elevation of over 11 km.



Turn to page 238 of the textbook and read “Stratospheric Ozone and CFCs.”

3. CFCs have been both useful and harmful.
 - a. Why were CFCs considered to be ideal for use in refrigerators, aerosol cans, and as forming agents?
 - b. If they are non-toxic, how did CFCs manage to damage the environment and threaten organisms?
 - c. What has the global community done to address the CFC problem?



Compare your responses with those in the Appendix on page 83.

Water Pollution

Have you seen a water filter attached to a faucet? These filters are supposed to filter out impurities such as bacteria, chlorine, lead, copper, and mercury. Some of these impurities are due to the improper disposal of waste into surface water.

This leads to an issue: What can and should be done to prevent water pollution? It would make sense to avoid releasing these impurities in the first place.



Turn to pages 239 and 240 of the textbook and read “Controlling Water Pollution in Surface Waters.”

4. Sewage must be treated properly.
 - a. What percentage of Canadians do not treat their waste water?
 - b. In the final stage, a water-treatment system can use plants to remove remaining pollutants. Name a plant that could be used for this purpose.
 - c. Create a flowchart to summarize tertiary waste water treatment in as few words as possible. Include the terms sewage (untreated waste water), effluent (treated waste water), primary, secondary, and tertiary in your chart.



Turn to page 241 of the textbook and read “Controlling Water Pollution in Ground Water.”

5. How might the following factors affect the dispersal of a chemical substance within the ground water? Be specific.
 - a. soil porosity
 - b. soil type
 - c. rock type
 - d. slope
6. Decisions must be made when dealing with issues. Many environmental issues have already been dealt with through legislation. What is your legal responsibility if you accidentally spill a significant quantity of a substance that may harm the environment?



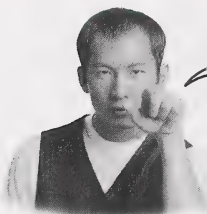
Compare your responses with those in the Appendix on page 83.

Biodegradation

biodegradation: the breaking down of materials by organisms such as earthworms, bacteria, and fungi

biodegradable substance: an organic material able to be broken down by bacteria, fungi, and other simple organisms

hazardous waste: waste-containing substances that are poisonous, corrosive, flammable, or explosive



Have you ever made a pile of grass clippings as you emptied a lawn-mower bag?



Yes, I have. I started the pile in late spring. Over the summer I added more grass clippings but the pile didn't get higher.



Grass clippings inside the pile started to break down through **biodegradation**—these products take less volume than the original clippings, which are made of **biodegradable substances**. Wait long enough and most of the grass may turn into carbon dioxide and water.



If waste from homes and industries could be broken down through biodegradation, wouldn't this solve the disposal problem?

Biodegradation would help. But **hazardous waste** is sometimes improperly disposed of and gets in the way.

Turn to page 242 of the textbook and read “Biodegradability and the Environment” for some answers.

7. Some wastes contaminate while others can break down into safe substances.

- How many litres of water can one drop of oil contaminate?
- Natural and synthetic substances that can be broken down by decomposers are classified as _____.
- Can a biodegradable substance be a pollutant? Explain.

8. Biodegradability is not the only factor that determines how environmentally friendly a substance is.
- From a biodegradability standpoint, is it better to use plastic or paper shopping bags? Explain.
 - Are plastic bags or kitchen wastes a more serious environmental pollutant? Why?



Compare your responses with those in the Appendix on page 84.

Hazardous Wastes



Turn to pages 244 and 245 of the textbook. Read “Hazardous Wastes” and the introduction to “Inquiry Investigation 3K: A Survey of Household Hazardous Wastes.”

9. Which of the following substances does not belong in this list? Why?

- ant poison
- prescription medicine
- dishwashing detergent
- glue
- nail polish remover

10. A certain class of solvents is considered to be hazardous.

- Is water an organic solvent? Explain.
- Why are all organic solvents dangerous?
- How can you reduce the risks of toxic organic solvents?
- What signal words are used on the labels of materials that are very hazardous?



11. Hazardous household products come in many forms. It is likely that you have some around your home. Look closely at the labelling of one hazardous household chemical. What safety labels are on it? Has the manufacturer included directions for safe use?

12. Certain plastics will degrade in the environment by photolysis. Write a definition for this term.



Compare your responses with those in the Appendix on page 84.

Going Further



Do you want to get a more complete picture of what hazardous materials are in your home? Then “Inquiry Investigation 3K: A Survey of Household Hazardous Wastes” is for you. You’ll find this investigation on pages 245 and 246 of the textbook. The investigation leads you through an in-depth survey of the potentially nasty substances which are right in your home.

Waste Management

When you toss a worn-out pair of gloves into the garbage, the gloves start on a journey. This trip likely ends in a landfill site. Fortunately, other things you throw away may not get there at all, thanks to modern waste management.

Recycling and recovering are components of waste management that you are sure to be familiar with.

DID YOU KNOW?



The City of Edmonton is recognized worldwide as a leader in waste management. Find out more from page 248 of the textbook.





Turn to pages 247 and 248 of the textbook and read “Waste Management—Back to the 4 Rs.”

13. The 4 Rs reduce the need for landfill.

- a. Which of them is the preferred option? Why?
- b. On average, what mass (how many kilograms) of unwanted material is generated by Canadians each day?
- c. Why is the production of recycled paper more environmentally friendly than paper made directly from the wood of trees?



Compare your responses with those in the Appendix on page 85.



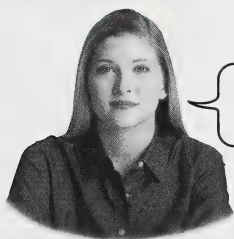
Turn to pages 249 and 250 of the textbook. Read “Landfill Construction and Design” and “Secure Landfills.”

14. There are various ways to store wastes, depending on their characteristics.

- a. How do secure landfills differ from sanitary landfills?
- b. Why must sanitary landfills have a clay liner?



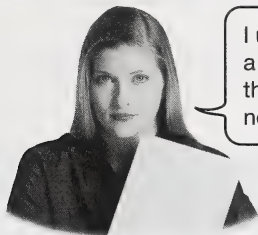
Compare your responses with those in the Appendix on page 85.



Buried garbage is not inert. It's biologically or chemically active.



I wouldn't want to dig into a garbage dump to find out what's going on in there.



I understand that. But you can make a small model of a landfill to see how things decompose. That's what the next “Going Further” is all about.

Going Further



The decomposition process can actually be very interesting. Do “Find Out Activity: Garbage In, Garbage Out?” on page 251 of the textbook. This activity provides a clean hands-on experience with a scientific study of garbage.

Bioremediation

A group of students researched the use of living things to process wastes. They decided to share their findings.



Plants can be used to absorb pesticides, hydrocarbons, heavy metals, pesticides, leachates, and radioactive materials through their roots. After a long enough growth period the plants can be collected, and then burned or composted.



Certain bacteria can be used to degrade PCBs buried in landfills. These bacteria remove the chlorine atoms from the molecules and replace them with hydrogen atoms. They then use the new molecules for food.



There's another type of bacteria that's a major weapon in the fight against oil pollution. Bacteria that feed on hydrocarbons such as oil, diesel fuel, and gasoline are cultured. These bacteria are then sprayed over areas that have been devastated by an oil spill. As bacteria feast on the oil, the oil is biodegraded. This speeds up the clean-up and recovery process.

bioremediation:
a method of
using living
organisms to
break down
complex, toxic
substances into
simpler,
non-toxic
substances

The students described different aspects of **bioremediation**.

Turn to page 252 of the textbook and read “Bioremediation—Mother Nature to the Rescue.”

15. Suggest the meaning of the term *phytoremediation*.
16. List three factors that affect the rate at which organisms break down substances during bioremediation.



Compare your responses with those in the Appendix on page 86.

17. Turn to page 252 of your textbook and answer questions 3 to 5 of “Topic 6 Review.”



Compare your responses with those in the Appendix on page 86.

You can now apply your understanding of biology and chemistry. In the next “Going Further” you can be involved in a decision about building a chemical plant in your neighbourhood. You will need to ask your family or friends to take on different roles in a decision-making process.

Going Further

Analyze an issue, decide where you stand, and then take action! Refer to “Unit 3: An Issue to Analyze—Not in My Backyard” on pages 256 and 257 of the textbook. Use these pages to guide your dramatization.



Looking Back

In this lesson you investigated potential risks that come from consumer practices and industrial waste. You studied the distribution of pollutants through soil, water, and air.

A great deal of progress has been made in the technology of solid waste reduction, recovery, treatment, and storage. It’s important to know that you really can’t simply throw wastes away—at least, not in the long run.

You’ve become aware that you have a part to play in solving pollution problems. You can make responsible and informed choices when confronted with environmental issues.

Lesson 4: Wrap-up

The following questions will help you review and apply the work you studied in this section.

Turn to page 253 of your textbook and answer questions 1, 4, 7, 9, and 11 of “Wrap-up: Topics 4 to 6.”

Check your answers with your teacher or home instructor.



Section 2 Conclusion



In this section you identified pollutants and pollution sources. You also learned about toxicity, risk assessment, environmental monitoring, water quality, and waste management. You then applied this knowledge in making decisions relating to pollution and the health of the environment.

You have the power to improve the health of your environment. There are many big and small ways to do this.

One way to counter the problems of pollution involves preventing hazardous materials from getting into the environment in the first place. If that has not been done, cleaning up the pollutants that have escaped is a way to improve the health of the environment.



Turn to Assignment Booklet 3B. Complete questions 8 to 12 from Section 2.

Module Summary



In this module you investigated the role of chemical substances in the environment. You studied the characteristics of a variety of chemical pollutants. Knowledge about toxicity and risk assessment are needed to evaluate the threat of pollutants. Acid/base reactions in the environment were investigated. Assessing and monitoring water quality made you aware of the need for waste management. You also found that informed decision-making can lead to wise environmental choices.

Yes, there are environmental choices and you can play a part in solutions. Personal and societal awareness through scientific knowledge provides the basis for action. Pollution assessment, monitoring, and management technologies are available to make such action effective.

The natural beauty of clear, clean air and water can be awe-inspiring. Pollutants may threaten such natural beauty. Fortunately, environmental choices that you make can save such beauty for the future.

Module Review

This review will help you apply the work you studied in Module 3.



Carefully read and study the concepts listed in “Unit at a Glance” on page 258 of the textbook before beginning the questions.

1. Answer questions 1, 4, 5, 8 to 11, 15, 19, 20, 25, and 33 from “Understanding Key Concepts” on pages 258 to 260 of the textbook.
2. Refer to the graphing guidelines in “Drawing a Line Graph” on pages 474 and 475 of the textbook.

A scatterplot is a graph that shows the relationship between two variables. The best-fit line is a line drawn through the set of points of the graph. This line shows the overall trend within the data.

Refer to this data table as you answer the questions that follow.

The Effect of Temperature on Oxygen Concentration	
Temperature (°C)	Oxygen Concentration (ppm)
15.0	6.8
18.0	6.5
25.5	5.9
24.5	6.0
24.0	5.8
22.0	6.1
27.0	5.7
29.0	5.4
17.0	6.7
29.5	5.3

You may use a computer spreadsheet to make your graph.

Note: Check the definition of *interpolate* in the Appendix if you don't remember this process.

Note: Check the definition of *extrapolate* if you don't remember what it is.

- a. Graph information in the data table as a scatterplot. Include a line of best fit.
- b. Use your graph to write an inference about the relationship between temperature and the oxygen concentration of water.
- c. Refer to the line of best fit. Interpolate what the likely oxygen concentration would be at 20°C. **Hint:** Read interpolation values off the line of best fit.
- d. Refer to the line of best fit. Extrapolate what the average oxygen concentration would be at 9°C. **Hint:** Read extrapolation values off the line of best fit.
- e. Based on your line of best fit, do you think a strong relationship exists between the two variables? Explain.



Check your answers with your teacher or home instructor.



Turn to Assignment Booklet 3B and do the Final Module Assignment.

Appendix



Glossary



Suggested Answers



Image Credits



Glossary

acid: a substance soluble in water with a pH of less than 7

An acid turns blue vegetable colours to red colours.

acid-base neutralization: when an acid and a base react with each other, the products (water, a salt, and sometimes a gas) are neutral

acid precipitation: snow, hail, or fog which is more acidic than normal precipitation

Atmospheric water mixes with chemicals (sulfur and nitrogen oxides) released by vehicles and industries.

active transport: a process in which cells use energy to move nutrient molecules from areas of lower concentration to areas of higher concentration

The direction of active transport is opposite to the direction of osmosis.

acute toxicity: the ability of a substance to cause harm to an organism with the first exposure

aerobic: an environment or process that contains or requires oxygen

algal bloom: a large increase in the algae population due to increased levels of nutrients in a water system

anaerobic: an environment or process that does not contain or require oxygen

aquifer: the zone of groundwater saturation (All pores and spaces in rock or soil are filled.)

The surface of the aquifer forms the water table.

base: a substance with a pH of more than 7

A base can be neutralized by an acid.

bioaccumulation: an increase in the concentration of a substance in an organism's body over time to a level higher than the level in the environment

The substance must be absorbed from the environment faster than it is excreted by or broken down in the organism's body.

biodegradable substance: an organic material able to be broken down by bacteria, fungi, and other simple organisms

biodegradation: the breaking down of materials by organisms such as earthworms, bacteria, and fungi

biological indicator: a living organism whose state is indicative of conditions in a particular environment

biomagnification: the process where chemicals accumulate in the tissues of organisms along the food chain

Chemicals that accumulate in this way are fat soluble. Fat-soluble chemicals are stored in the fat tissue of bodies. Water-soluble chemicals do not undergo biomagnification since they are excreted by the kidneys.

Biomagnification is also called bioaccumulation.

bioreactor: a bioremediation tank that provides optimal conditions for the chosen decomposers

bioremediation: a method of using living organisms to break down complex, toxic substances into simpler, non-toxic substances

buffer: a substance that in solution is capable of neutralizing added acids or bases and thereby maintaining the original acidity or alkalinity of the solution

A buffer is also a solution that resists pH change due to the presence of such a substance.

carbohydrate: an organic compound composed of either a single sugar unit or chains of sugar units bonded together (e.g., simple sugars, starch, cellulose, glycogen)

catalyst: a substance that speeds up a chemical reaction without being used up in the process

chemical indicator: a substance containing a chemical that changes colour according to acidity or alkalinity

chronic toxicity: the ability of a substance to cause harm to an organism with repeated exposures

diffusion: the movement of particles within a fluid from higher (more particles) to lower (fewer particles) concentrations

effluent: waste material, usually wastewater, discharged into the environment

enzyme: a special protein molecule that regulates chemical reactions in living organisms

Enzymes are catalysts for biochemical reactions.

extrapolate: to estimate an unmeasured value that goes beyond known or measured data

fungicide: a chemical used to kill fungi

ground water: water that is found beneath Earth's surface in the pores and cavities of rock and soil

hazardous waste: waste-containing substances that are poisonous, corrosive, flammable, or explosive

herbicide: a substance used to control or kill plant pests

indicator (pH): a chemical or combination of chemicals that provide a measurement of acidity through a change in colour

inorganic compound: generally, a compound whose molecules do not contain carbon atoms

insecticide: a substance used to control or kill insect pests

interpolate: to estimate an unmeasured value from within the range of known or measured data

LD50: the dose at which a chemical will kill 50% of the exposed population

leachate: water carrying dissolved and suspended substances it has picked up as it passes through soil or landfill

liming: adding calcium carbonate to the environment to neutralize and buffer acid precipitation

lipid: an organic nutrient that is insoluble in water (e.g., fat, oil, or wax)

litmus: a common acid/base indicator

macroinvertebrate: an organism visible to the unaided eye that does not have a backbone

macromineral: a mineral required by the body in amounts greater than 100 mg/day

nimby: someone who objects to the establishment in his or her neighbourhood of projects that are believed to be dangerous, unsightly, or otherwise undesirable

For example, a nimby would likely object to the development of a nearby incinerator, prison, or chemical plant. Nimby is an acronym for “not in my backyard.”

non-persistent wastes: wastes that can be fairly easily degraded in the environment

non-point source: a source of pollution in which pollutants are diffuse and don't originate from a specific location

nutrient: a chemical in food used for energy, growth, body building, or cell repair

organic agriculture: the production of food with the use of feed or fertilizers of plant or animal origin and without the use of chemical fertilizers, growth stimulants, antibiotics, or pesticides

organic compound: generally, a compound whose molecules contain carbon atoms

Carbon dioxide and carbon monoxide are exceptions—they are not considered to be organic compounds even though they contain carbon. You can think of organic compounds as being compounds of, relating to, or being derived from living organisms.

Compounds that are not organic are considered to be inorganic.

osmosis: diffusion of a solvent (usually water) through a selectively permeable membrane from regions of high water concentration to low water concentration

persistent: tending to accumulate in the environment and to break down very slowly, if at all

pesticide: a chemical applied to control pests

pH scale: a quantitative scale that indicates how acidic or alkaline a solution is

The pH scale ranges from 0 to 14. On this scale, acids have a pH of less than 7 (0 being the strongest), pH 7 is neutral, and alkaline or basic substances have pHs greater than 7 (14 is the strongest).

photolysis: the breakdown (lysis) of compounds through the absorption of sunlight (photo)

point source: a specific location where pollution originates

poison: a chemical that causes illness or death when absorbed or ingested

pollutant: a material or form of energy that will cause harm to living organisms

pollution: any alteration of the environment that produces a condition harmful to living things

The act of contaminating the environment with pollutants is pollution.

potable: safe to drink

protein: organic molecules made up of amino acid units

sanitary landfill: a landfill incorporating a waterproof liner filled with compacted garbage that is covered with earth

scrubber: a device that removes potentially polluting gases or particulates from industrial emissions

secure landfill: a specialized landfill that safely stores disposed hazardous wastes

sewage: solid and liquid wastes carried in pipes from domestic, commercial, and industrial areas to sewage treatment or storage facilities

solvent: a substance that can be used to dissolve another substance

sorbent: a substance that absorbs oxides

substrate: the base on which an organism lives

For example, soil is the substrate of most seed plants.

titration: the precise addition of a solution in a burette—or a graduated glass tube—into a measured volume of a sample solution

toxin: protein molecules produced by organisms that cause illness or death

A toxin is a type of poison.

trace element: a mineral that the body requires in an amount of less than 100 mg per day

trophic: having to do with food

vitamin: a molecule that aids enzyme functions in the body

Suggested Answers

Section 1: Lesson 1

1.
 - a. iodine
 - b. chlorine
 - c. iron or chromium
 - d. calcium or fluorine
 - e. iodine
 - f. vitamin C
 - g. potassium, copper, or calcium
2.
 - a. Carbon dioxide (CO_2) is inorganic. It's an exception. It contains carbon but is not organic.
 - b. Propane (C_3H_8) is organic.
 - c. Silicon dioxide (SiO_2) is inorganic—it contains no carbon atoms.
 - d. Glucose ($\text{C}_6\text{H}_{12}\text{O}_6$) is organic.
 - e. Sodium hydroxide (NaOH) is inorganic.
3.
 - a. The method of transfer is active transport. (Energy is used to transport glucose into cells where its concentration is higher.)
 - b. Active transport is the method of transfer. (Phosphorus and nitrogen are taken into the root hairs, where their concentrations are higher.)

- c. Osmosis is the method. (Water diffuses through the selectively permeable cellular membrane—the bacteria cell membrane—to where its concentration is lower.)
4. The minerals are in very low concentrations. Roots have a large surface area that allow plants to absorb the minerals and concentrate the minerals in their roots (up to 10 000 times greater than the soil concentration).
 5.
 - a. Oxygen makes up 49 % of the Earth's crust.
 - b. The concentration of oxygen is 75% of a generic plant.
 - c. The concentration of oxygen is 65% in a human body.
 6.
 - a. Oxygen, carbon, hydrogen, nitrogen, phosphorus, and sulfur are all found in higher concentrations in human tissue than they occur in the Earth's crust.
 - b. No, the concentration of silicon in plants and humans is very low compared to its concentration in the Earth's crust. Organisms obviously do not need much silicon, so they absorb very little.
 - c. Humans need sulfur more than plants do because there is five times more sulfur in human tissue. Sulfur atoms are components in the amino acids used to form proteins—a human has a lot more proteins than a plant does.
 7.

a. water	e. dirty snow
b. soil	f. bread
c. remnants of your food	g. air and also the rock it grows on
d. soil	

8. Textbook question 3 from “Analyze,” page 184:

3. Results will generally show that, up to a point, higher concentrations cause greater growth for both roots and shoots. Higher fertilizer concentrations can reduce plant growth or kill the plant due to dehydration or corrosive effects. Results will also vary with the chemical make up of the fertilizer.

Textbook questions 1 to 3 from “Conclude and Apply,” page 184:

1. The sample with no fertilizer in the water acted as a control sample. It allowed for a determination as to whether the fertilizer affected the experimental samples.
2. Answers will vary. An example is the following.

My results agreed to a point. I didn't realize that the highest concentration would actually make the plants grow less.

3. Nitrogen promotes both stem and leaf growth. Phosphorus promotes germination. If the first number (nitrogen) is larger, the shoots will likely be larger. If the second number (phosphorus) is larger, the roots will likely be larger.

Advice to neighbour: Use a fertilizer high in nitrogen and phosphorus—the first two elements listed. Phosphorus promotes germination and nitrogen promotes stem and leaf growth. Potassium (for flower and fruit formation) would not come into play in this investigation.

9. The nitrogen cycle is imitated.
10. Atmospheric nitrogen is fixed by soil bacteria to form ammonia in the soil. Other bacteria change ammonia to the nitrates in the soil that plants can absorb.
11. Potash provides potassium.
12. The amount of worldwide crop production has doubled since 1950, aided by new high-yield varieties. And marginal land can now be used to grow successful crops.

Note: Although there are benefits to the use of artificial fertilizers, there are also some harmful effects. The following are negatives:

- Excess fertilizer drains into water systems and causes algal blooms.
- Soil can be damaged by overuse.
- Chemical fertilizers do not return fibre to the soil—this affects its ability to hold water and resist erosion.

13. Textbook questions 2 and 3 of “Topic 1 Review,” page 186:

2. People need more than 100 mg of macrominerals each day and less than 100 mg of trace elements in the same time period.
3. Plants provide people with essential elements and minerals as well as organic compounds such as proteins, carbohydrates, lipids, and vitamins.

Note this added benefit of having plants in your diet—plants provide fibre. The bulk of fibre promotes the movement of food through the digestive tract and protects against certain medical conditions—especially bowel diseases.

Section 1: Lesson 2

1. Herbicides control weeds, insecticides control insects, and fungicides control fungus pests.

2. Textbook question from “Pause and Reflect,” page 188:

Answers will vary. An example is the following.

It’s important to understand the food relationships between organisms because organisms are tied together in complex food webs. When one species in a food chain or web is negatively affected by human actions, an unintended chain reaction can affect a wide variety of non-target organisms. This reaction could include humans, their pets, and wild species that humans consider desirable. Removing one pest can promote an increase in the population of other even less desirable pests. Scientific knowledge of food chains and webs decreases the chances of making serious errors. Knowledge allows humans to minimize negative effects and helps identify alternative, and less negative, methods for dealing with a pest.

3. Answers will vary. The following is an example.

If not using DDT means that my children will likely die or suffer from starvation, malnutrition, or disease, I would almost certainly use DDT. I would worry more about keeping them alive and as healthy as possible than I would worry about possible consequences in the distant future. I would hope that if there were negative long-term consequences, a solution would have been developed. While I might care about people in other countries, my children’s survival and health would be of far greater importance to me.

4. a. About 10 species were resistant to insecticides in 1940.

b. In 1990, about 510 species of insects and mites were resistant to insecticides.

5. Non-target organisms include

- butterflies
- bees
- fish
- frogs
- birds (ospreys, hawks, and eagles, as well as non-predatory birds that ate affected fish, plankton, insects, and earthworms)
- dolphins
- squid
- people

6. Textbook questions 1, 2, 3, 5, 7, and 9 from page 191:

1. DDT dissolves into water. Photosynthesizing organisms such as plants and phytoplankton absorb it along with the water they use for photosynthesis. As a stable, non-excretable chemical, DDT bioaccumulates in their bodies.
 2. The dolphin has the highest DDT level.
 3. Dolphins are at a higher trophic (food) level.
 5. The fish have DDT levels 430 000 times greater than the seawater. The concentration in the dolphins is 52 million times greater.
 7. The DDT could be carried in the atmosphere or in the water system.
 9. It is likely that the DDT killed non-target animals as well. These animals may have been competitors or predators of the target animals. Predators may have been affected indirectly through biomagnification or directly through a loss of food, or via negative health or reproductive effects.
7. a. Organic agriculture uses *natural processes and cycles* to minimize environmental damage and optimize productivity.
- b. The development and testing of new pesticides requires careful observation of the effects of a pesticide on all organisms, not just on its intended target.
8. No! Chemicals produced by plants or animals can be just as harmful as synthetic chemicals. Consider the venom of a snake or the poison produced by the hemlock plant.
9. Answers will vary. Note the following possibilities:
- biological control with natural predators, competitors, or disease
 - crop rotation leaving species-specific pests without a food source
 - altering growth conditions to make them unfavourable for the pests (e.g., limit shelter and breeding sites in the crop)
 - crop plant modifications through selective breeding or genetic engineering to make plants more resistant or less attractive to pests
 - the release of sterilized male insect pests
 - the application of insect hormones to prevent sexual maturity
 - the use of insect pheromones to lure insect pests into traps

- using manure instead of chemical fertilizers
- planting two or three crops in alternating rows in the same field
- using proven natural chemicals as pesticides, such as sulfur and boron (though these are usually less effective than more toxic chemicals)

10. Textbook questions 3, 4, and 6 of “Topic 2 Review,” page 196:

3. A toxin is a poison that causes an immune system (antibody) response. Poisons kill or sicken organisms by chemical action.
4. Answers will vary. An example is the following.

Organic farming techniques avoid the use of synthetic chemicals. Food grown organically is less likely to have been exposed to poisons. Organic foods cost more because they can only be grown on a small scale—their production is much more labour-intensive. Pests reduce their yield. Organic farming is better for human and environmental health but it would be impossible to produce enough food to supply the huge human population without the use of more conventional modern farming methods.

6. The biomagnification of stable, non-excretable toxins causes the concentration of some chemicals to reach levels that threaten the health and reproduction of organisms near the top of the food chain.

Section 1: Lesson 3

1. a. A c. B
b. B d. A
2. a. A c. D
b. C d. B

3. Note this memory cue: Red litmus turns blue in a bitter base.

You can infer that solution 1 is a base and solution 2 is an acid. Solution 3 is neutral. Litmus paper provides no further indication of pH.

Note: To get a more precise indication of acidity, you can use a meter or a more specific pH indicator. Universal indicators respond to all or most of the pH range. Other indicators can give quite precise readings within a specific range (e.g., 0.0 to 3.0).

4. The following substances are ordered in increasing pH:

- car battery acid
- normal rain
- human blood
- baking soda
- household ammonia
- drain cleaner

5. a. The common pH indicators generally have ranges from about 1 to 12.

b. The universal pH indicator papers provided results that were more accurate. There is a previously established and tested colour strip scale to compare with the results of the unknown samples. The scale was in even graduations.

6. **Textbook questions 1 from “Analyze” and 3 from “Conclude and Apply,” page 203:**

1. Answers will vary depending on the substances sampled.

The suggested solutions have approximate pHs as follows:

- The pH of lemon juice is 2.
- The pH of vinegar is 2.
- The pH of coffee is 5.
- The pH of club soda is 6.
- The pH of rainwater is 6. It's neutral to slightly acidic (varies with the substances that dissolve in it while it is in the atmosphere or on the ground).
- The pH of distilled water or tap water is 7. It's neutral. (There would be more variation in tap water due to dissolved substances.)
- The pH of shampoo is 8.
- The pH of antacid is 11.
- The pH of ammonia is 11.

The solutions should be listed from the lowest pH to the highest pH.

3. The ammonia makes the water slightly basic. When carbon dioxide is bubbled through water, an acid must have been produced (carbonic acid) because the solution became less basic or perhaps even became neutral as indicated by the colour change of the cabbage juice indicator.

7. At least 50% of the acid precipitation in eastern Canada originates in the United States. It is then carried north by atmospheric currents.
8.
 - a. Marble is metamorphosed limestone. You may remember the acid test for limestone (calcium carbonate)—hydrochloric acid reacts with calcium carbonate to release hydrogen gas bubbles. Acid also reacts with marble to erase the features on marble statues and limestone buildings.
 - b. Acid precipitation causes soil to become nutrient poor by dissolving minerals and allowing them to leach out of the soil. This releases deadly, heavy metals from the soil into ground and surface waters. These poisons are consumed or absorbed by organisms.
9.
 - a. Carbonic acid, formed when carbon dioxide reacts with water, lowers the pH of rainwater.
 - b. Acid fog in Los Angeles has reached pHs as low as 1.7, which is 10 000 times more acidic than normal rain.
 - c. Acidified lakes can be limed. Powdered limestone (calcium carbonate) is used to neutralize acid in the lake water.

10. Textbook questions 1 from “Analyze” and 2 and 3 from “Conclude and Apply,” page 206:

1. Answers may vary. According to the given data table of the student results, the yeast population showed the most growth at a pH of 7.
2. (a) Aquatic insects appear to be the most sensitive to acid conditions. Their populations drop off quite quickly and they disappear first.

Algae appear to be the least sensitive. Their populations drop off quite slowly. They still exist below pH 4.0.

- (b) While the fish may be able to tolerate the acidity, the populations of the organisms they eat can decline—this can cause the fish to die off. Adult fish may be tolerant of acidification, but the higher acidities may kill or damage developing eggs or young fish.

- (c) Answers will vary. An example is the following.

I agree. The populations of aquatic insects have already severely declined by the time fish begin to die off. Aquatic insects are near the base of the food chain so their populations affect the populations of most of the other organisms. Aquatic insects would be a better indicator species—they are the most sensitive group of organisms.

3. Answers will vary. Note the following example.

The more pH is lowered by acid precipitation, the more it negatively affects organisms living in the water. Acid precipitation negatively affects some organisms more than others. All organisms are eventually affected by acid precipitation because it removes key organisms from the food chain.

11. Note the following data table.

Acid-Base Titration			
Solution	pH of Alkaline Solution	Relative Strength Rating (Strong, Medium, Weak)	Number of Drops of Acid Required to Neutralize the Base
sodium hydroxide (drain cleaner)	14	strong	25
baking soda	8.2	weak	5
antacid (e.g., milk of magnesia)	10.5	medium	15

12. Textbook question 2 from “Analyze,” page 208:

2. A mass of 2 g of baking soda was used to prepare its solution.

The data table “Acid-Base Titration,” shows the number of drops of acid that neutralized each of three bases. The number of drops of acid is also the volume of the acid that each of the bases can neutralize.

The baking soda can neutralize only one-third the volume of acid that the sample of antacid can.

In order to neutralize the same amount of acid as the antacid, three times the baking soda that was actually used is needed.

In the investigation, 2 g of baking soda was used. Therefore 3×2 g or 6 g of baking soda is needed. That means 6 g of baking soda is “equal” to the sample of antacid used in the experiment.

13. a. If acidic water continues to enter lakes, more and more calcium carbonate must be added as it gets used up. Also, all neutralization reactions produce salt. You may simply end up trading one problem for another.
- b. Catalytic converters and scrubbers remove oxide emissions.
- c. The coal mined in Alberta has a low sulfur content. **Note:** Another reason is that Alberta is not downwind of any major industrial areas or large cities.

14. Textbook questions 1 to 5 from “Topic 3 Review,” page 211:

1. Burning fossil fuels in cars, power-generating plants, and factories produces most of the acid precipitation precursors (sulfur, nitrogen, and carbon oxides) that combine with water to form acids.
2. All acid-base indicators change colour to indicate pH. Some provide very accurate pH readings, some provide readings over a broad range, and others only indicate that a substance is an acid or a base.
3. These creams would likely be basic/alkaline.
4. Add each chemical to a different sample of the cabbage juice universal pH indicator. The one that turns green or gold is the base. The one that turns from blue to red is the acid.
5. This compound is called sodium fluoride. This is a neutralization/exchange reaction.



Section 1: Lesson 4

Check your answers with your teacher or home instructor.

Section 2: Lesson 1

1. Textbook questions 1 and 2 from “Analyze” and 4 from “Conclude and Apply,” page 215:

1. In each dilution, concentration changes by a factor of 10. There are six dilutions going from glass 1 to glass 7. Glass 1 would be a million times more concentrated than glass 7.
2. Answers will vary. The number of taste and smell sensors varies from person to person. Some people will be able to detect the salt or sugar in much lower concentrations than others are able to.
4. In a double-blind study, neither the subjects nor the investigator knows the composition of the study and control groups during the actual course of the study. And they don't know the “correct” response. A double-blind study would be used to prevent the investigator from giving non-verbal clues to the subjects.

2. Use the following calculation.

$$10 \text{ mg salt}/250 \text{ g water} = 0.04 \text{ mg/g}$$

$$0.04 \text{ mg/g} \times 1000 \text{ g/kg} = 400 \text{ mg/kg or } 400 \text{ mg/L or } 400 \text{ ppm}$$

Remember: 1 mg/kg of water = 1 mg/L of water = 1 ppm

3. a. In the one billion-kilogram sample, there would be 0.05 kg of mercury, 1.3 kg of arsenic, and 9.4 kg of lead.
- b. Yes, the water is potable. The levels of the mineral concentrations in the water are below the maximums allowed by the Government of Canada guidelines. The maximums permitted are shown in the data table on page 217 of the textbook.

Note: Here's a way of visualizing the concept of parts per million, billion, or trillion:

- 1 ppm—1 drop of food colouring in 99 999 drops of water (about half a bathtub)
- 1 ppb—1 drop of food colouring in 99 999 999 drops of water (about one swimming pool)
- 1 ppt—1 drop of food colouring in 99 999 999 999 drops of water (about 1000 swimming pools)

4. a. No, it does not exceed the LD50 dose as given for nicotine in “Table 3.4.”

b. Yes, the value of 0.0000055 ppm does exceed the LD50 dose as given for tetanus toxin A in “Table 3.4.”

5. Waiting periods are important because

- not all individuals or species react in the same way to a new chemical (a medication for one may be a toxin for another)
- individual tolerances to chemical concentrations vary
- the method, timing, and length of exposure can influence the effect
- animal research lowers the chance but does not ensure that humans will not react negatively to new chemicals
- many effects only become known over time

6.
 - a. For many people, drinking coffee is an *acceptable* risk.
 - b. *Every* chemical has the potential to be harmful, depending on the *dose*, *individual susceptibility*, and *how the chemical reacts with other chemicals*.

7. **Textbook questions 4 and 5 of “Topic 4 Review,” page 221:**

4. Answers will vary. Following is an example of the kind of thinking that goes into an answer.

As “snowfall,” the carbon covers surfaces and prevents sunlight from reaching photosynthesizing organisms. Yet, in some forms, carbon is not hazardous but beneficial. When carbon is contained in water filters, carbon removes impurities from water. If the “snowfall” is just carbon, it may actually help by removing toxins from the air. On the other hand, when carbon removes such toxins, the carbon becomes laden with toxins and is hazardous when it reaches the water. If the water is polluted, it will have less aquatic life in it than a similar body of water away from the factory.

5. Answers will vary. The term refers to the dose of a chemical necessary to kill half of a population that it’s applied to. LD50 is a more accurate way of reporting, because it is based on the effects on many organisms.

Note: LD50 refers to a dosage, not a population size.

Section 2: Lesson 2

1.
 - a. B, C, D, A
 - b. You know the water sample contains phosphate if a precipitate forms.
 - c. Answers will vary. You could weigh the amount of precipitate formed from a standardized sample. By using a standardized sample of 50 mL, you would be able to assume that the mass of precipitate formed would be proportional to the phosphate concentration.
2. The steps should be done in this order: H, B, D, G, A, C, F, E.
3. **Textbook question 3 from “Analyze,” page 227:**
 3. Distilled water is pure water. There should be nothing dissolved or suspended in it! The distilled water acted as a control. You know that the fertilizer water will contain phosphates and nitrates unless the package specifies otherwise. The fertilizer water allows you to see how the tests work.
 4.
 - a. A precipitate forms.
 - b. The sample turns pink.

5. Each drop corresponds to 0.5 ppm. Therefore, 16 drops corresponds to $16 \times 0.5 \text{ ppm} = 8 \text{ ppm}$.

The dissolved oxygen content was 8 ppm.

6. Each drop corresponds to 5 ppm. Therefore, three drops corresponds to $3 \times 0.5 \text{ ppm} = 15 \text{ ppm}$.

The dissolved carbon dioxide content was 15 ppm.

7. Answers will vary. The following are reasonable inferences.

- Tap water, containing the chlorine, was used to make solutions.
- The aquarium water was dechlorinated or distilled.

8. The dissolved oxygen and dissolved carbon dioxide concentrations are higher than in the other samples. The higher oxygen concentration indicates that the aquarium must have an aerator (air pump) that bubbles air through the water. Like turbulence, bubbling air through water creates more contact and allows more oxygen to dissolve into the water.

The high carbon dioxide concentrations indicate that there are few, if any, plants in the water. Organisms produce carbon dioxide during cellular respiration. Plants use carbon dioxide to photosynthesize. If plants were present the carbon dioxide levels in the water would likely be quite low.

9. The dissolved oxygen level is very low for a natural water system. It is unlikely that there are many species living in this pond because the oxygen level is far too low. There may have been an algal bloom in this pond. The decomposers use up the oxygen—this makes the pond unlivable for most organisms.

If there was an algal bloom and the pond is near a field, it is likely that excess fertilizer drained into the pond and caused the bloom. The high levels of phosphates and nitrates in the water support this inference. The presence of fertilizer in the water could account for the alkaline pH of the pond water.

10. Textbook questions 1 and 2 of “Analyze” and 3 from “Conclude and Apply,” page 229:

1. Sample X (cold pond water) required ten drops of sodium thiosulfate.

$$10 \times 0.5 \text{ ppm} = 5 \text{ ppm of dissolved oxygen}$$

Sample Y (previously hot pond water) required two drops of sodium thiosulfate.

$$2 \times 0.5 \text{ ppm} = 1 \text{ ppm of dissolved oxygen}$$

2. Sample X (cold pond water) required two drops of sodium hydroxide.

$$2 \times 5 \text{ ppm} = 10 \text{ ppm of dissolved carbon dioxide}$$

Sample Y (previously hot pond water) required one drop of sodium hydroxide.

$$1 \times 5 \text{ ppm} = 5 \text{ ppm of dissolved carbon dioxide}$$

3. The higher the temperature, the lower the ability of water to contain dissolved oxygen.
11. Sample X is just above the critical oxygen content for supporting aquatic life. Fish would likely find it difficult to live in this water. Very few organisms could live in sample Y water.
12. The fish could die out. If the temperature of the water increases, the oxygen content would decrease. If it decreases too much, the fish may be unable to successfully reproduce or even survive. There is a possibility that increased temperatures could increase plant growth in the lake. More plants could maintain or increase oxygen content, especially if the water remains open in the winter to allow more photosynthesis. Constant monitoring of the dissolved oxygen content of the lake would be very important.
13. These fish could live in turbulent mountain streams. The water released by melting snow and ice is cold. The water running swiftly down steep, rocky slopes would be very turbulent or agitated. Cold, turbulent water should have a high oxygen content.
14. a. Water pollution often lowers the oxygen concentration of the water.
b. Water pollution usually affects the diversity of organisms present in the water.
c. Lichens are very sensitive to changes in the pH of air.
15. No, they are vertebrate bioindicators. They have backbones. As bioindicators, the presence of trout indicates good water quality, while catfish can live in poor quality water.
16. a. The biochemical oxygen demand suddenly increases in the “Decomposition Zone” because high populations of decomposers use a lot of oxygen as they break down waste.
b. The “Decomposition Zone” and the “Recovery Zone” are characterized by the same types of animals.
c. The zones gradually blend into each other because chemical and biological factors gradually change along the length of the stream.
17. a. No, there could be high concentrations of toxins in the water. Judging water quality by a single indicator is not a good idea, even though pollutants often decrease oxygen content.

- b. As populations of invertebrates that require high oxygen concentrations decline, the populations of organisms that are connected to them through the food web will change as well. Decreasing competitor or predator populations would allow the populations of organisms requiring less oxygen to increase.

A decrease in the populations of food species would cause a decrease in the populations of reliant species. (This decrease would also cause a switch to other food sources that would result in a decrease in that food source's population.)

- c. The following are estimates of oxygen levels.

- (i) The oxygen level is from 6 to 8.
- (ii) The Site B number is from 4 to 6.
- (iii) The number should be more than 7.
- (iv) The oxygen level is about 4.

Comment: It is difficult to be more precise when you only look at one indirect factor.

18. a. The feedlot is a point source since it's a single specific source of pollution.
b. This is a non-point source since it releases pollutants from over a large area.

19. Textbook question 3 from “Topic 5 Review,” page 235:

3. These chemicals promote the growth of algae. Excessive algal growth first decreases the amount of light available to organisms below the algae—this causes population changes. Then, as the affected organism and dying algae decompose, the biochemical oxygen demand sharply increases. This causes oxygen levels to sag below the level at which most organisms can survive.

Section 2: Lesson 3

1. Answers will vary. The following is an example.

Like most people, I am a nimby. My family produces a wide variety of solid and liquid wastes each day. I know that waste has to go somewhere but I sure don't want a garbage dump or sewage treatment plant close to my home! I think litter is really ugly but I still occasionally leave garbage lying around because it's easier than finding a garbage can. I enjoy long showers, new clothing, and toys. I prefer to have my parents drive me places rather than walking, riding my bicycle, or taking the bus. I like the house warm and I frequently leave lights on unnecessarily. All of these things produce wastes that I choose not to think about. I could do more to reduce my effect on the environment.

2. a. The average transit time for pollutants to be carried to Canada by the circumpolar winds is three days.
- b. PCBs are spread from industrialized areas by wind and currents to distant food chains where they bioaccumulate. The Arctic food chain that provides the Inuit diet is also affected by PCBs from distant sources.
3. a. CFCs were cheap, stable, and non-toxic.
- b. CFCs damage the ozone layer, which normally protects life from damaging UV light.

You may be curious about how this happens. CFCs absorb ultraviolet light energy and break down to produce chloride ions. The chloride ions act as a catalyst for the breakdown of ozone into normal oxygen gas. Ozone is a chemical that prevents much of the UV radiation from reaching the earth's surface—oxygen does not prevent this. Overexposure to UV radiation causes cell damage and cancer.

- c. About 80 countries have signed an agreement to stop the production and use of CFCs.
4. a. About 43% of Canadians do not have their waste water treated.
- b. The water hyacinth can be used for waste water treatment.
- c. Answers will vary. The following flowchart is an example.

Note: Most treatment plants do not yet have tertiary treatment lagoons. The treatment system summarized includes information for the more commonly used tertiary treatment system. The information in brackets is optional information to make the flowchart more meaningful to you.

Waste Water Treatment: Sewage to Effluent

sewage → primary treatment (physical treatment: filter) → settle → secondary treatment (biological treatment: add decomposers and air to remove biodegradable waste) → settle → tertiary treatment (chemical/biological treatment: chemical processing to remove dissolved chemicals and suspended solids/trickling bed evaporator or marsh plus chlorine or UV light to kill micro-organisms): → effluent

5. a. The more porous the soil, the faster chemicals will move through it. Compact soils like clay can slow or prevent the movement of toxins in ground water.
- b. Some soils will react with pollutants that buffer against their effects. Other soils will release natural pollutants such as mercury when exposed to some pollutants. Soils with lots of humus will absorb pollutants and slow their dispersal. Sandy soil would allow pollutants to disperse very quickly.

- c. Permeable rocks will allow pollutants to disperse through them. Permeable rock can act as an aquifer. Toxins can become concentrated in aquifers. Aquifers usually filter out bacteria. Rock may be inert or it may react with pollutants to decrease the concentration of pollutants. Impermeable (impervious) rock prevents ground water from sinking any deeper and channels its movements.
- d. With all other factors being equal the steeper the slope of the ground, the faster ground water moves.

6. Answers will vary. The following is an example.

If I accidentally spill a significant quantity of a substance that may harm the environment, it is my legal responsibility to take all reasonable measures to

- repair, remedy, and confine the effects of the substance
- safely remove or dispose of the substance
- restore the environment

7. a. Twenty-five litres of water can be contaminated by one drop of oil.
- b. Natural and synthetic substances that can be broken down by decomposers are classified as *biodegradable*.
- c. Yes, a biodegradable substance can be a pollutant. Even though a substance can be broken down by decomposers, it can still be harmful. Some biodegradable substances break down into toxic substances.
8. a. Paper bags are a better choice because they degrade in two to five months, while it takes plastic bags 10 to 20 years to degrade.
- b. Kitchen wastes can be a more serious pollutant because they may release harmful gases and leachate as they decompose.
9. Dishwashing detergent does not belong in the list because it is not a hazardous household substance like the other chemicals may be. **Note:** Dishwashing detergent is harmful if ingested.
10. a. Water is not an organic solvent because its molecules do not contain carbon atoms.
- b. Organic solvents are poisonous if swallowed or inhaled and can cause
- rashes
 - dizziness
 - nausea
 - fatigue
 - loss of co-ordination
 - brain damage

Organic solvents also evaporate quickly, can burn or explode, and are often difficult to detect.

c. Toxic organic solvents should be

- stored in their original containers
- clearly labelled
- stored in dry, secure locations away from heat and open flames
- tightly capped with childproof lids

d. *Danger* and *poison* are words used on the labels of very hazardous materials.

11. Answers will vary, depending on what product is chosen. For example, one example of aerosol furniture polish has the following information provided on its labelling.

Safety labels include poison, flammable, and explosive safety symbols.

Safety directions include the following:

- The direct inhalation of spray can be harmful.
- Use under well-ventilated conditions.
- Do not use in the presence of open flames or sparks.
- Do not place in hot water or near a heat source.
- Do not puncture or incinerate the container.
- Do not store in temperatures above 50°C.
- This product contains petroleum distillate—if swallowed, call a physician or poison control centre immediately.

12. Photolysis is the breakdown of compounds through the absorption of sunlight.

13. a. Of the 4 Rs, *reduce* will have the largest overall impact.

b. $30\,500\,000 \text{ people} \times 2 \text{ kg/person} = 61\,000\,000 \text{ kg per day.}$

c. Recycled paper requires 58% less water and produces 74% less air pollution than paper made from trees. It also avoids habitat destruction since trees are not used in its production.

14. a. Secure landfills are used for hazardous and toxic wastes. A layer of gravel and a plastic liner are used in addition to two or more layers of impervious compacted clay. Thick layers and walls are used to separate the stacks of chemical-containing barrels. Like a sanitary landfill, a grid of pipes in the gravel layer collects leachate that is pumped out for treatment. Test wells are located around the site to monitor for escaping contaminants.

b. The clay liner prevents leachate from escaping into the ground water supplies.

15. *Phyto* refers to plants. *Remediation* is a cure or correction for a problem. Phytoremediation uses plants to correct for pollution. Such plants reduce the concentration of pollutants in the soil and water. These plants take up pollutants through their roots.

16. Factors that affect the break down of substances include

- pressure
- temperature
- pH level
- availability of oxygen

Note: There are other factors that affect the rate. These are

- the chemical structure of the material being decomposed
- the micro-organism population
- the plant population
- moisture
- nutrient availability

Most decomposers require a warm, moist, oxygenated environment with a pH that is fairly close to neutral. Plants have a mutual relationship with several beneficial micro-organisms. A higher plant population allows higher microbe populations.

17. Textbook questions 3 to 5 of “Topic 6 Review,” page 252:

3. Ground water is found below the surface between soil particles, in porous rock, or rock chambers. The water table is the level to which the substrate is “filled” with water. Surface water is visible in lakes, sloughs, rivers, and oceans.
4. Hazardous wastes are poisonous, toxic, corrosive, flammable, or explosive. Answers will vary. Examples include
 - paint
 - nail polish remover
 - deodorizing spray
 - glue
 - toilet cleaner

5. Note the following equation.

$$\frac{15 \text{ trees}}{1200 \text{ kg paper}} \times 150\,000 \text{ kg paper/month} \times 12 \text{ month/year} = 22\,500 \text{ trees/year}$$

Every year, 22 500 trees are saved.

The equation in this solution involved the conversion of units through cancellation. To become more familiar with cancellation in an equation, see “Example of the GRASP Problem-Solving Method” in Skill Focus 3 on pages 451 and 452 of the textbook. You can find additional examples of cancellation in “Skill Focus 4” on pages 453 and 454 of the textbook.

Section 2: Lesson 4

Check your answers with your teacher or home instructor.

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